SCIENTIFIC AMERICAN SUPPLEMENT

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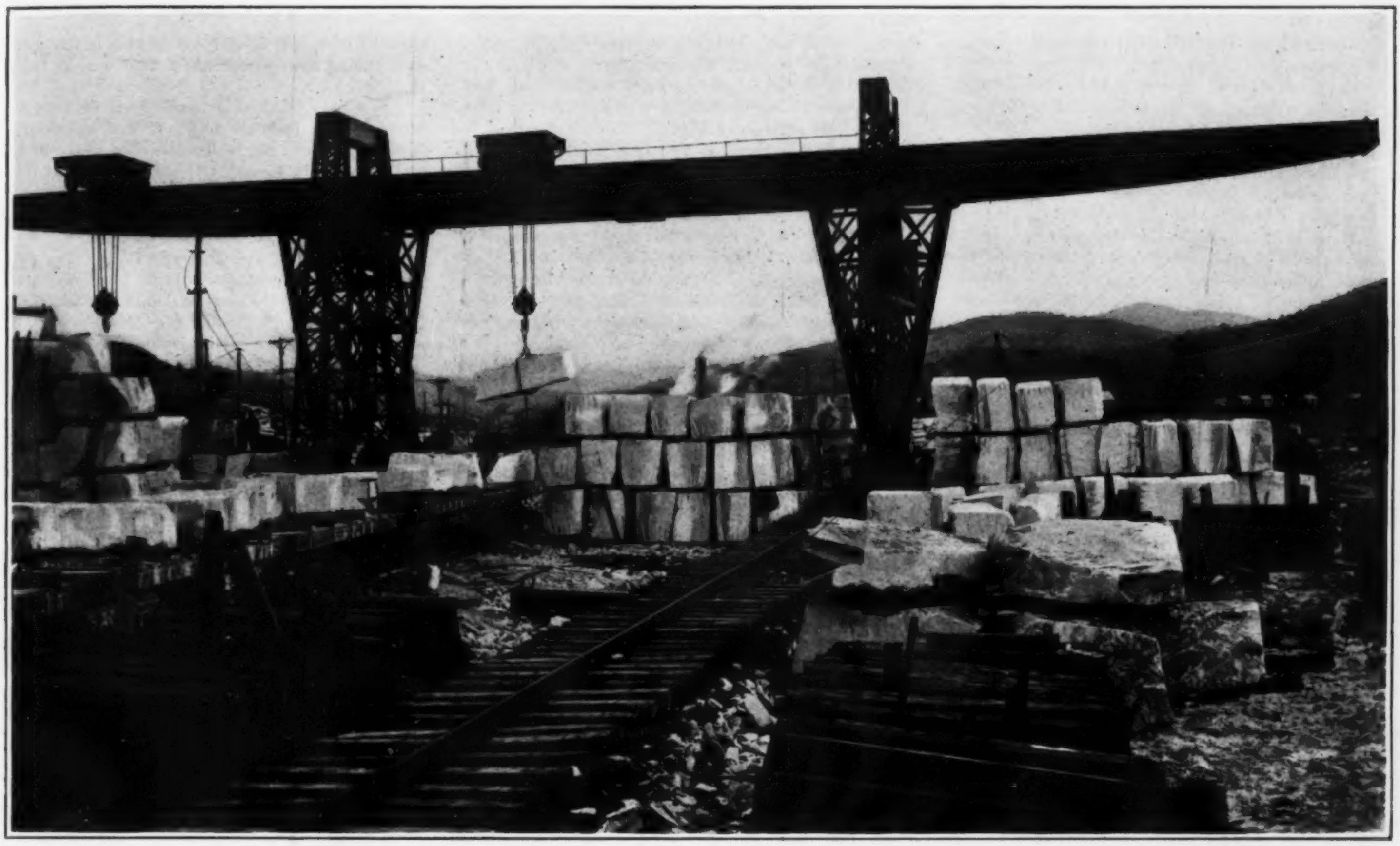
VOLUME LXXXII
NUMBER 2118

★ NEW YORK, AUGUST 5, 1916 ★

$5.00 A YEAR
10 CENTS A COPY



Large gantry crane for handling blocks in the storage yards.

A powerful electric locomotive that does the hauling in underground galleries.

AN ELECTRICALLY-OPERATED MARBLE QUARRY.—[See page 88.]

Infantile Paralysis*

Its Nature, Manner of Conveyance and Means of Prevention

By Simon Flexner, M.D., Director of Laboratories of Rockefeller Institute

The Rockefeller Institute for Medical Research has been appealed to by so many physicians and laymen for information and advice on the subject of infantile paralysis that it has seemed desirable to relate the facts of present knowledge concerning certain highly pertinent aspects of the disease together with deductions of practical importance derived from them.

Infantile paralysis is an infectious and communicable disease which is caused by the invasion of the central nervous organs—the spinal cord and brain—of a minute, filterable micro-organism which has now been secured in artificial culture and as such is distinctly visible under the higher powers of the microscope.

The virus of infantile paralysis, as the micro-organism causing it is termed, exists constantly in the central nervous organs and upon the mucous membrane of the nose and throat and of the intestines in persons suffering from the disease; it occurs less frequently in the other internal organs, and it has not been detected in the general circulating blood of patients.

VIRUS IN HEALTHY PERSONS.

Although the micro-organism of infantile paralysis is now known, the difficulties attending its artificial cultivation and identification under the microscope are such as to make futile the employment of ordinary bacteriological tests for its detection. Nevertheless, the virus can be detected by inoculation tests upon monkeys, which animals develop a disease corresponding to infantile paralysis in human beings. In this manner the fact has been determined that the mucous membrane of the nose and throat of healthy persons who have been in intimate contact with acute cases of infantile paralysis may become contaminated with the virus, and that such contaminated persons, without falling ill themselves, may convey the infection to other persons, chiefly children, who develop the disease.

The virus has apparently an identical distribution irrespective of the types or severity of cases of infantile paralysis. Whether the cases correspond with the so-called abortive forms of the disease in which definite paralysis of the muscles does not occur at all, or is so slight and fleeting as often to escape detection; whether they correspond with the meningeal forms in which the symptoms resemble those of acute meningitis with which muscular paralysis may or may not be associated; or whether they consist of the familiar paralytic condition, the virus is present not only within the nervous organs, but also upon the mucous membranes of the nose, throat and intestines.

ESCAPE OF VIRUS FROM THE BODY.

Micro-organisms which convey disease escape from the body of an infected individual in a manner enabling them to enter and multiply within fresh or uninfected individuals in such a manner as to cause further disease. The virus of infantile paralysis is known to leave the infected human body in the secretions of the nose, throat and intestines. It also escapes from contaminated healthy persons in the secretions of the nose and throat. Whether it ever leaves the infected body in other ways is unknown.

At one time certain experiments seemed to show that biting insects, and particularly the stable fly, might withdraw the virus from the blood of infected persons and inoculate it into the blood of healthy persons. But as the virus has never been detected in the blood of human beings and later experiments with the stable fly have not confirmed the earlier ones, this means of escape of the virus must be considered doubtful. On the other hand, it has been shown by experiments on animals, so that the same facts should be regarded as applicable to human beings, that the virus seeks to escape from the body by way of the nose and throat, and not only when inoculation takes place through these membranes, but also when the inoculation is experimentally made into the abdominal cavity, the blood, or the brain itself. From this it is concluded that the usual means of escape of the virus is by way of the ordinary secretions of the nose and throat, and after swallowing these, with the discharges of the intestines.

ENTRANCE OF VIRUS INTO THE BODY.

The virus enters the body, as a rule, if not exclusively, by way of the mucous membrane of the nose and throat. Having gained entrance to those easily accessible parts of the body, multiplication of the virus occurs there, after which it penetrates to the brain and spinal cord by way of the lymphatic channels which connect the upper nasal membrane with the interior of the skull. Whether the virus ever enters the body in any other way is unknown. Certain experiments already alluded to make it possible that it may be inoculated into the blood by insects and other experiments have shown that under peculiar and extraordinary conditions it may in monkeys enter through the intestines.

But while the latter two modes of infection may operate sometimes, observations upon human cases of infantile paralysis and upon animals all indicate that the main avenue of entrance of the virus into the body is by way of the upper respiratory mucous membrane; that is, the membrane of the nose and throat.

The physical properties of the virus of infantile paralysis adapt it well for conveyance to the nose and throat. Being contained in their secretions, it is readily distributed by coughing, sneezing, kissing, and by means of fingers and articles contaminated with these secretions, as well as with the intestinal discharges. Moreover, as the virus is thrown off from the body mingled with the secretions, it withstands for a long time even the highest summer temperatures, complete drying, and even the action of weak chemicals, such as glycerin and carbolic acid, which destroy ordinary bacteria.

Hence mere drying of the secretions is no protection; on the contrary, as the dried secretions may be converted into dust which is breathed into the nose and throat, they become a potential source of infection. The survivial of the virus in the secretions is favored by weak daylight and darkness, and hindered by bright daylight and sunshine. It is readily destroyed by exposures to sunlight.

Since epidemics of infantile paralysis always arise during the period of warm or summer weather they have been thought of as possibly being connected with or dependent on insect life. The blood sucking insects have especially come under suspicion. Experiments have been made with biting flies, bedbugs, mosquitoes and with lice. Neither mosquitoes nor lice seem able to take the virus from the blood of infected monkeys or to retain it for a time in a living state. In one instance bedbugs have been made to take up the virus from the blood of monkeys, but they did not convey it by biting to healthy monkeys.

Certain experiments did indicate that the biting stable fly could both withdraw the virus from the blood of infected and reconvey it to the blood of healthy monkeys, which became paralyzed. But more recent studies have failed to confirm the earlier ones. Moreover, experimentally inoculated monkeys differ in one way from human beings suffering from infantile paralysis, for while the virus may appear in the blood of the former it has never been detected in the blood of the latter. The ordinary or domestic fly may become contaminated with the virus contained in the secretions of the body and serve as the agent of its transportation to persons and to food with which it comes into contact.

Domestic flies experimentally contaminated with the virus remain infective for forty-eight hours or longer. While our present knowledge excludes insects from being active agents in the dissemination of infantile paralysis they nevertheless fall under suspicion as being potential mechanical carriers of the virus of that disease.

The attention which the recent epidemic of infantile paralysis has drawn to the disease attended by paralysis has led to the discovery that domestic animals and pets are subject to paralytic diseases. The animals which have especially come under suspicion as possibly distributing the germ of infantile paralysis are poultry, pigs, dogs and cats. But in isolated instances sheep, cattle and even horses have been suspected. All these kinds of animals are subject to diseases in which paralysis of the legs and other parts of the body sometimes appear. In not a few instances paralytic diseases among poultry or pigs have been noted to coincide with the appearance of cases of infantile paralysis on a farm or in a community.

Experimental studies have, however, excluded the above mentioned animals from being carriers of the virus of infantile paralysis. The paralytic diseases which they suffer have long been known and are quite different from infantile paralysis. Their occurrence may be coincidental; in no instance investigated has one been found to be responsible for the other.

FOLLOWS ROUTES OF TRAVEL.

Studies carried out in various countries in which infantile paralysis has been epidemic all indicate that, in extending from place to place or point to point, the route taken is that of ordinary travel. This is equally true whether the route is by water or land, along a simple highway or the line of a railroad. In other words, the evidence derived from this class of studies confirms the evidence obtained from other sources in connecting the distributing agency intimately with human beings and their activities.

The virus of infantile paralysis is destroyed in the interior of the body more quickly and completely than, in some instances, in the mucous membrane of the nose and throat. It has been found in monkeys, in which accurate experiments can be carried out, that the virus may disappear from the brain and spinal cord within a few days to three weeks after the appearance of the paralysis, while at the same time it is still present upon the mucous membranes mentioned.

The longest period after inoculation in which the virus has been detected in the mucous membrane of the nose and throat of monkeys is six months. It is far more difficult to detect the human than the monkey carriers of the virus, since, as directly obtained from human beings, the virus displays a low degree of infectivity for monkeys; while, once adapted to monkeys, the virus becomes incredibly active, so that minute quantities are capable of ready detection by inoculation tests. Yet in an undoubted instance of the human disease the virus was detected in the mucous membrane of the throat five months after its acute onset. Hence we possess conclusive evidence of the occurrence of occasional chronic human carriers of the virus of infantile paralysis.

Not all epidemics of infantile paralysis are equally severe. Indeed great variations or fluctuations are known to occur not only in the number of cases, but also in the death rate. The extremes are represented by the occasional instances of infantile paralysis known in every considerable community and from which no extension takes place, and the instances in which in a few days or weeks the number of cases rises by leaps and bounds into the hundreds, and the death rate reaches 20 per cent or more of those attacked. While all the factors which determine this discrepancy are not known, certain of them have become apparent.

A factor of high importance is the infective power or potency, or, technically stated, the virulence, of the micro-organism or virus causing the disease. This virus is subject to fluctuation of intensity which can best be illustrated by an example. The virus as ordinarily present in human beings even during severe epidemics has low infective power for monkeys. But by passing it from monkey to monkey it tends to acquire, after a variable number of such passages, an incredible activity. However, occasional samples of the human virus refuse to be thus intensified. But once rendered highly potent, the virus may be passed from monkey to monkey through a long but not indefinite series.

Finally, in some samples of the virus at least a reverse change takes place—the virus begins to lose its virulence until it returns to the original or even to a diminished degree of infective power. In this respect the behavior of the virus corresponds to the onset, rise and then the fall in number and severity of cases as observed in the course of epidemics of infantile paralysis and other epidemic diseases.

Hence either a new active specimen of the virus may be introduced from without which, after a certain number of passages from person to person, acquires a high potency; or a specimen of virus already present and left over from a previous epidemic, after a resting period and similar passages, again becomes active and reaches an infective power which equals or even exceeds that originally possessed. Another but more indefinite factor relates to the degree of susceptibility among children and others affected, which at one period may be greater or less than at another.

VARYING INDIVIDUAL SUSCEPTIBILITIES.

Not all children and relatively few adults are susceptibile to infantile paralysis. Young children are more susceptible, generally speaking, than older ones; but no age can be said to be absolutely insusceptible. When several children exist in a family or in a group, one or more may be affected, while the others escape or seem to escape. The closer the family or other groups are studied by physicians, the more numerous it now appears are the number of cases among them. This means that the term infantile paralysis is a misnomer, since the disease arises without causing any paralysis whatever, or such

*A statement made at a meeting under the auspices of the Academy of Medicine, New York, July 13th.

slight and fleeting paralysis as to be difficult of detection.

The light or abortive cases, as they are called, indicate a greater general susceptibility than has always been recognized; and their discovery promises to have far reaching consequences in respect to the means employed to limit the spread or eradicate foci of the disease.

Like all other infectious diseases, infantile paralysis does not arise at once after exposure, but only after an intervening lapse of time called the period of incubation. This period is subject to wide limits of fluctuation; in certain instances it has been as short as two days, in others it has been two weeks or possibly even longer. But the usual period does not exceed about eight days. Probably the period at which the danger of communication is greatest is during the very early and acute stage of the disease. This statement must be made tentatively since it depends on inference, based on general knowledge of infection, rather than on demonstration. Judging from experiments on animals, the virus tends not to persist in the body longer than four or five weeks except in those exceptional instances in which chronic carriage is developed. Hence cases of infantile paralysis which have been kept under supervision for a period of six weeks from the onset of the symptoms may be regarded as practically free of danger.

Infantile paralysis is one of the infectious diseases in which insusceptibility is conferred by one attack. The evidence derived from experiments on monkeys is conclusive in showing that an infection which ends in recovery gives protection from a subsequent inoculation. Observations upon human beings have brought out the same fact, which appears to be generally true, and to include all the forms of infantile paralysis, namely, the paralytic, meningeal, or abortive, which all confer immunity.

BASIS OF THE IMMUNITY EXPLAINED.

The blood of normal persons and monkeys is not capable of destroying or neutralizing the effect of the virus of infantile paralysis. The blood of persons or monkeys who have recovered from the disease is capable of destroying or neutralizing the effect of the virus. The insusceptibility or immunity to subsequent infection, whether occurring in human beings after exposure or monkeys after inoculation, rests on the presence of the destroying substances, the so-called immunity bodies which arise in the internal organs and are yielded to the blood. So long as these immunity bodies persist in the body protection is afforded, and their presence has been detected twenty years or even longer after recovery from infantile paralysis. Experiments have shown that the immunity bodies appear in the blood in the course of even the mildest attack of the disease, which fact explains why protection is afforded irrespective of the severity of the case.

Protection has been afforded monkeys against inoculation with effective quantities of the virus of infantile paralysis by previously subjecting them to inoculation with sub-effective quantities or doses of the virus. By this means and without any evident illness or effect of the protective inoculation complete immunity has been achieved. But the method is not perfect since in certain intances not only was immunity not obtained, but unexpected paralysis intervened. In the instances in which protection was accomplished the immunity bodies appeared in the blood.

PASSIVE PROTECTION RELATIVELY SHORT.

By transferring the blood of immune monkeys to normal or untreated ones, they can be rendered insusceptible or immune, and the immunity will endure for a relatively short period during which the passively transferred immunity bodies persist. The accomplishment of passive immunization is somewhat uncertain, and its brief duration renders it useless for purposes of protective immunization.

On the other hand, a measure of success has been achieved in the experimental serum treatment of inoculated monkeys. For this purpose blood serum derived either from recovered and protected monkeys or human beings has been employed. The serum is injected into the membranes about the spinal cord, and the virus is inoculated into the brain. The injection of serum must be repeated several times in order to be effective.

Use of this method has been made in a few instances in France, where the blood serum derived from persons who had recovered from infantile paralysis has been injected into the spinal membranes of persons who have just become paralyzed. The results are said to be promising. Unfortunately the quantity of the human immune serum is very limited, and no other animals than monekys seem capable of yielding an immune serum and the monkey is not a practicable animal from which to obtain supplies.

ONLY ONE DRUG TREATMENT.

The virus of infantile paralysis attacks and attaches itself to the central nervous organs. Hence it is reached not only with difficulty because nature has carefully protected those sensitive organs from injurious materials which may gain access to the blood, but it must be counteracted by substances and in a manner that will not themselves injure those sensitive parts. The ideal means to accomplish this purpose is through the employment of an immune serum, since serums are among the least injurious therapeutic agents.

The only drug which has shown any useful degree of activity is hexamethylenamin, which is itself germidical, and has the merit of entering the membranes, as well as the substance of the spinal cord and brain in which the virus is deposited. But experiments on monkeys have shown this chemical to be effective only very early in the course of the inoculation and only in a part of the animals treated.

PRACTICAL DEDUCTIONS AND APPLICATIONS.

1. The chief mode of demonstrated conveyance of the virus is through the agency of human beings. Whether still other modes of dissemination exist is unknown. According to our present knowledge, the virus leaves the body in the secretions of the nose and throat and in the discharges from the intestines. The conveyers of the virus include persons ill of infantile paralysis in any of its several forms and irrespective of whether they are paralyzed or not, and such healthy persons who may have become contaminated by attendance on or association with the ill.

How numerous the latter class may be is unknown. But all attendants on or associates of the sick are suspect. These healthy carriers rarely themselves fall ill of the disease; they may, however, be the source of infection in others. On the other hand, the fact that infantile paralysis is very rarely communicated in general hospitals to other persons, whether doctors, nurses, or patients, indicates that its spread is subject to ready control under restricted and supervised sanitary conditions.

2. The chief means by which the secretions of the nose and throat are disseminated is through the act of kissing, coughing, or sneezing. Hence during the prevalence of an epidemic of infantile paralysis care should be exercised to restrict the distribution as far as possible through these common means. Habits of self denial, care and cleanliness and consideration for the public welfare can be made to go very far in limiting the dangers from these sources.

Moreover, since the disease attacks, by preference, young children and infants, in whom the secretions from the nose and mouth are wiped away by mother or nurse, the fingers of these persons readily become contaminated. Through attentions on other children or the preparation of food which may be contaminated, the virus may thus be conveyed from the sick to the healthy.

The conditions which obtain in a household in which a mother waits on the sick child and attends the other children are directly contrasted with those existing in a well ordered hospital; the one is a menace, the other a protection to the community. Moreover, in homes the practice of carrying small children about and comforting them is the rule, through which not only the hands but other parts of the body and the clothing of parents may become contaminated.

3. Flies also often collect about the nose and mouth of patients ill of infantile paralysis and feed on the secretions, and they even gain access to the discharges from the intestines in homes unprotected by screens. This fact relates to the domestic fly, which, becoming grossly contaminated with the virus, may deposit it on the nose and mouth of healthy persons, or upon food or eating utensils. To what extent the biting stable fly is to be incriminated as a carrier of infection is doubtful; but we already know enough to wish to exclude from the sick, and hence from menacing the well, all objectionable household insects.

Food exposed to sale may become contaminated by flies or from fingers which have been in contact with secretions containing the virus; hence food should not be exposed in shops and no person in attendance upon a case of infantile paralysis should be permitted to handle food for sale to the general public.

4. Protection to the public can be best secured through the discovery and isolation of those ill of the disease, and the sanitary control of those perons who have associated with the sick and whose business calls them away from home.

In the first place, where homes are not suited to the care of the ill so that other children in the same or adjacent families are exposed, the parent should consent to removal to hospital in the interest of the sick child itself, as well as in the interest of other children. But this removal or care must include not only the frankly paralyzed cases, but also the other forms of the disease.

In the event of doubtful diagnosis, the aid of the laboratory is to be sought, since even in the mildest cases changes will be detected in the cerebrospinal fluid removed by lumbar puncture. If the effort is to be made to control the disease by isolation and segregation of the ill, then these means must be made as inclusive as possible. It is obvious that in certain homes isolation can be carried out as effectively as in hospitals.

But what has been said of the small incidence of cases of the disease among the hospital personnel and those with whom they come into contact, indicates the extent to which personal care of the body by adults and responsible people can diminish the menace which those accidentally or unavoidably in contact with the ill are to the community.

Care exercised not to scatter the secretions of the nose and throat by spitting, coughing and sneezing, the free use of clean handkerchiefs, cleanliness in habits affecting especially the hands and face, changes of clothes, etc., should all serve to diminish this danger.

In the end, the early detection and isolation of the cases of infantile paralysis in all of its forms, with the attendant control of the households from which they come, will have to be relied upon as the chief measure of staying the progress of the epidemic.

LESS THAN OTHER DISEASES.

5. The degree of susceptibility of children and other members of the community to infantile paralysis is relatively small and is definitely lower than to such communicable diseases as measles, scarlet fever and diphtheria. This fact in itself constitutes a measure of control; and while it does not justify the abatement of any practicable means which may be employed to limit and suppress the epidemic, it should tend to prevent a state of over-anxiety and panic from taking hold of the community.

6. A percentage of persons, children particularly, die during the acute stage of the disease. This percentage varies from five in certain severe epidemics to twenty in others. The average death rate of many epidemics has been below 10 per cent. A reported high death rate may not be actual, but only apparent, since in every instance the death will be recorded, while many cases which recover may not be reported at all to the authorities.

In the present instance it is too early in the course of the epidemic to calculate the death rate, which may prove to be considerably lower than it now seems to be.

7. Of those who survive a part make complete recoveries, in which no crippling whatever remains. This number is greater than is usually supposed, because it includes not only the relatively large number of slight or abortive cases, but also a considerable number of cases in which more or less of paralysis was present at one time. The disappearance of the paralysis may be rapid or gradual—may be complete in a few days or may require several weeks or months.

The remainder, and unfortunately not a small number, suffer some degree of permanent crippling. But even in this class the extent to which recovery from the paralysis may occur is very great. In many instances the residue of paralysis may be so small as not seriously to hamper the life activities of the individual; in others in whom it is greater it may be relieved or minimized by suitable orthopedic treatment.

YEARS FOR FULL RECOVERY.

But what it is imperative to keep in mind is that the recovery of paralyzed parts and the restoration of lost muscular power and function is a process which extends over a long period of time; that is, over months and even years. So that even a severely paralyzed child who has made little recovery of function by the time the acute stage of the disease is over may go on gaining for weeks, months, and even years until in the end he has regained a large part of his losses.

Fortunately, only a very small number of the attacked are left severely and helplessly crippled. Lamentable as it is that even one should be so affected, it is nevertheless a reassurance to know that so many recover altogether and so much of what appears to be permanent paralysis disappears in time.

There exists at present no safe method of preventive inoculation or vaccination, and no practicable method of specific treatment. The prevention of the disease must be accomplished through general sanitary means; recovery from the disease is a spontaneous process which can be greatly assisted by proper medical and surgical care.

Infantile paralysis is an infectious disease, due to a definite and specific micro-organism or virus; recovery is accomplished by a process of immunization which takes place during the acute period of the disease. The tendency of the disease is toward recovery and it is chiefly or only because the paralysis in some instances involves those portions of the brain and spinal cord which control respiration or breathing and the heart's action, that death results.

Finally, it should be added that not since 1907, at which time the great epidemic of infantile paralysis, or poliomyelitis, appeared in this country, has the country or this State or city been free of the disease. Each summer since has seen some degree of accession in the number of the cases; the rapid rise in the number of cases this year probably exceeds that of any previous year.

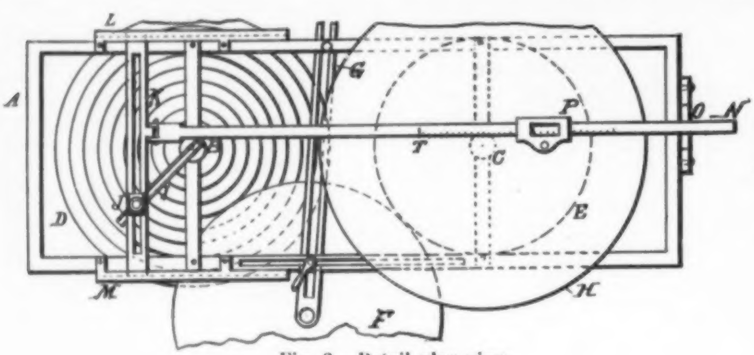


Fig. 2.—Detail plan view.

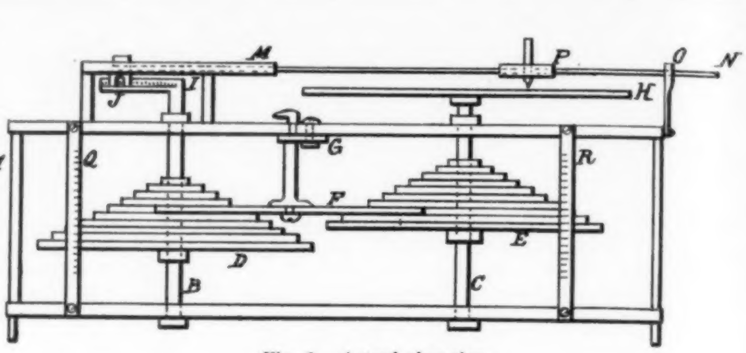


Fig. 3.—Actual elevation.

The Cyclo-Harmonograph

An Instrument for Drawing Large Classes of Important Higher Plane Curves

By Robert E. Moritz, Prof. Mathematics, University of Washington

Next to the straight line, the conic sections (including the circle), and the simple harmonic curves, few curves are of more frequent occurrence and of greater theoretical importance than the cardioids, the *limaçons*, and the foliate curves or rosettes (French *rosaches*, German *Rosenkurven*). When it is desirable or necessary to construct such curves the method commonly employed is to plot the curve by points from their equations. Thus to construct the cardioid, $\rho = 1 + \cos\theta$, arbitrary values are assigned to the angle θ and the corresponding values of ρ are computed. Each value of θ and the corresponding value of ρ determine a point of the curve, and a sufficient number of points having been thus located, the required curve is obtained by drawing a smooth curve through these points.

It is evident that this process is necessarily laborious and far from accurate, for it involves an accumulation of errors—the error in approximating $\cos\theta$ for a given value of θ, the errors involved in the construction of θ, the values of θ, and the corresponding values of ρ, and errors incident to drawing a smooth curve through given points.

All these errors may be eliminated and the curves laid out with the greatest ease and utmost precision by employing a simple instrument which compels the pencil or pen point to move according to the mathematical law which defines the curve. The curve is thus generated by the continuous motion of a point, comparable to the commonly employed method of constructing a circle by means of a pair of compasses. In fact, the circle itself is among the many curves that come within the range of the instrument.

The circle, the cardioid, the *limaçon*, the rosettes, and many other curves have the common property that they may be represented by equations of the form $\rho = a\cos\frac{p}{q}\theta + k$, where ρ, θ are polar co-ordinates and a p, q, and k properly chosen constants. For rosettes $k = 0$, for the circle, cardioid, and *limaçon* $p = q$ and $k = 0$, a, and $\frac{a}{2}$, respectively, for $p = 2q$ and $a = 2k$ we have the curve known as the nephroid, for $p = 2q$ and $a = k$, the double-egg curve and so on.

The intrinsic reason for the importance of these curves and the frequency of their occurrence is no doubt to be sought in the fact that such curves may be obtained from a composition of a simple harmonic with a uniform circular motion, for obviously the equation $\rho = a\cos\frac{p}{q}\theta + k$ results from the elimination of t from the two equations $\rho = a\cos pt + k$ and $\theta = qt$, of which the first represents a simple harmonic motion, amplitude a, wave length $2\pi/p$, k being the distance of the neutral point of vibration from the origin, and the second represents a circular motion, q being the unit of angular velocity. Any curve whose equation may be put in the form $\rho = a\cos\frac{p}{q}\theta + k$ may, therefore, be appropriately designated by the term *cyclic-harmonic curve* and defined as *the locus of a point which has simple harmonic motion in a straight line while at the same time this line rotates uniformly about one of its points.*

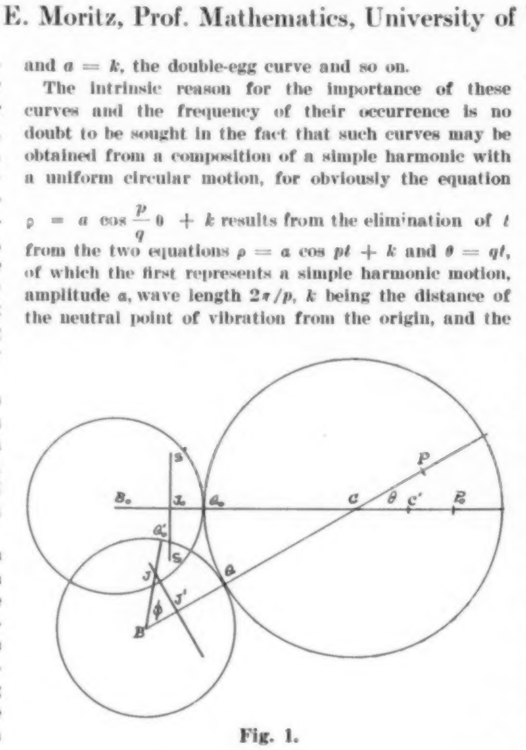


Fig. 1.

The foregoing observation and consequent definition suggest the possibility of constructing these curves kinematically.

Consider two wheels B and C (Fig. 1) which for practical reasons are connected by an idle-wheel, but which, so far as the theory of the instrument is concerned, may be thought of as having rolling contact. The wheel B carries a crankpin J, which, as the wheel revolves, slides in a slotted crossbar JJ' of a crosshead $J'P$ perpendicular to JJ'. The crosshead is constrained to move in the direction of the line of centers BC. If the wheel B is made to roll at a uniform rate along the circumference of the wheel C, any point P on the crosshead will have simple harmonic motion along the line BC, while the line BC itself turns with uniform angular velocity about C as a center. The point P therefore describes a curve having the property above mentioned.

To derive the equation of the curve described by the point P, let B_0 denote the initial position, B any subsequent position of the rolling wheel, Q_0 and Q the respective points of contact of the wheels B and C, Q_0' the new position of the point Q_0 considered as a point on the circle B. Let q and p denote the radii of the wheels B and C respectively, ϕ the angle through which B has turned with reference to the line of centers, θ the angle between the two lines of centers. Let P_0 represent the initial position of P, which is so chosen that $CP_0 = a + k$, where $a = B_0J_0 = CC'$ and k is any arbitrary distance $C'P_0$. If now C is chosen as the center of co-ordinates, CP_0 as the direction of the polar axis and ρ, θ as the polar co-ordinates of the point P, we have

$$\rho = CP = BJ' + J'P - BC;$$

but $BJ' = BJ\cos\phi = a\cos\phi$, since $BJ = B_0J_0 = a$; $J'P = J_0P_0 = B_0C + C'P_0 = BC + k$, so that $J'P - BC = k$, and we have

$$\rho = a\cos\phi + k.$$

But from the fact that the two arcs Q_0Q and $Q_0'Q$ are equal, we further have $BQ\,.\,\phi = CQ\,.\,\theta$, that is $q\phi = p\theta$, from which $\phi = \frac{p}{q}\theta$ so that finally

$$\rho = a\cos\frac{p}{q}\theta + k.$$

In explaining the theory of the instrument we have assumed that the wheel B rolls on the circumference of the fixed wheel C. The same result will be obtained if both wheels are permitted to rotate about their fixed centers, the paper on which the curve is to be drawn being attached to the face of the wheel C.

Figs. 2 and 3 represent two projections of the working parts of the complete instrument shown in Fig. 4.

The framework A supports two shafts B and C, each of which carries a set of wheels D and E. Each set of wheels admits of being raised or lowered and of being clamped at any desired position on the shaft, so that any wheel of either set may be brought into the plane of the idle-wheel F, which serves to connect the two sets of wheels. The necessary adjustment in the position of the idle-wheel for the various combinations of wheels is effected by means of a slotted bar G, which carries the idle-wheel.

The shaft C has secured to its upper extremity a circular disk H, which serves to hold the paper on which the curve is to be drawn.

The shaft B terminates in a crankarm I, to which is clamped a crankpin J. This crankpin works in a slide K, whose extremities move in two grooved parallel

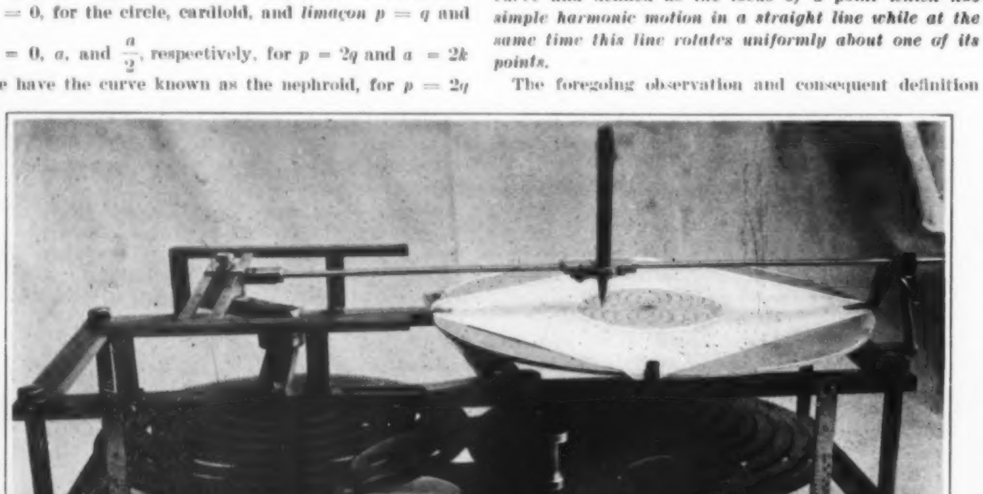


Fig. 4.—The cyclo-harmonograph.

guides L and M. Near the middle of the slide K is fastened the tracer-arm N, which slides in a fixed support O and carries the tracer-slide P for the reception of the tracing pencil or pen.

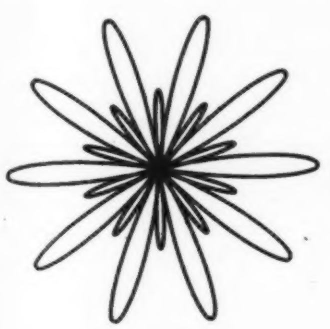
The tracer-arm N and the crankarm I are graduated to facilitate in the setting of the tracer-slide P and the crankpin J at various distances. Two graduated scales Q and R facilitate the adjustment of the various wheels to the plane of the idle-wheel F.

To draw any desired curve of the form $\rho = a \cos \frac{p}{q} \theta + k$ we now proceed as follows: The wheel of diameter p of set E and the wheel of diameter q of set D are connected by the idle-wheel F. The crankpin J is set at the distance a from the center of the shaft B, and the tracer-slide P is set at the distance k from the neutral point T of the tracer-arm N. A sheet of paper is fastened to the disk H, and the pencil or pen point inserted at P is brought in contact with the paper. On turning the idle-wheel by hand the pencil will draw

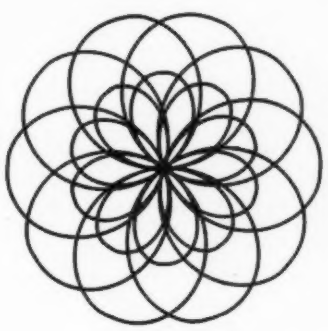
the curve $\rho = a \cos \frac{p}{q} \theta + k$.

The cycloharmonograph shown in Fig. 4 contains 10 wheels in each set with diameters proportional to the numbers from 1 to 10 respectively. This adapts the instrument to the description of 63 distinct species of curves, each species being characterized by a distinct ratio p/q. a and k admit of all values within the limits

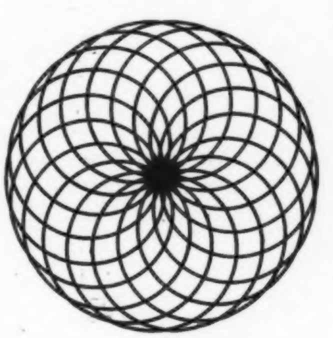
$a \lesssim 3$ inches, $k \lesssim 5$ inches $a + k \lesssim 6$ inches.



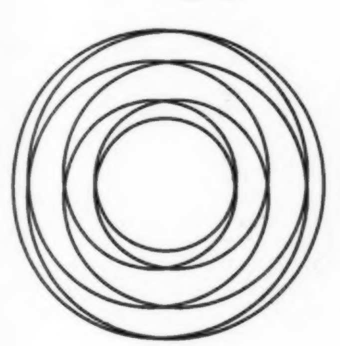
$\rho = a \left(\cos \frac{\theta}{10} + \frac{1}{3} \right)$



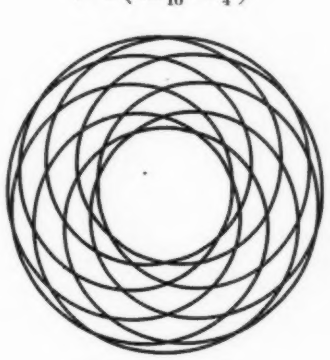
$\rho = a \left(\cos \frac{7}{10} \theta + \frac{1}{4} \right)$



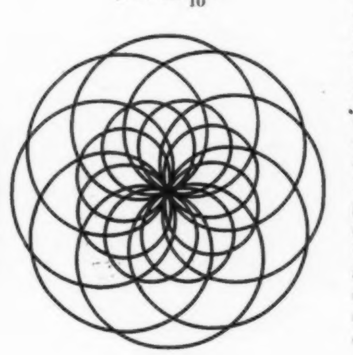
$\rho = a \cos \frac{9}{10} \theta$



$\rho = a \left(\cos \frac{2}{7} \theta + \frac{7}{3} \right)$



$\rho = a \left(\cos \frac{7}{9} \theta + \frac{7}{3} \right)$



$\rho = a \left(\cos \frac{8}{9} \theta + \frac{1}{4} \right)$

Specimens of harmonic curves that can be drawn by the cyclo-harmonograph.

Experimental Biology

We use in our title the term Experimental Biology, which requires some apology, as a convenient label for an interesting bundle of thirteen papers by Jacques Loeb and Hardolph Wasteneys. They give an account of important experiments bearing on a variety of puzzling biological problems. (1) Loeb showed many years ago (1889) that some animals orient themselves in relation to a luminous object so that their plane of symmetry falls into the direction of the rays of light, and suggested that this reaction was comparable to the heliotropic reaction of plants. In 1897 he brought forward evidence in support of the view that the action of light in evoking a heliotropic reaction is chemical, and this theory is now confirmed by additional facts.

According to the law of Bunsen and Roscoe, the photochemical effect of light is equal to the product of the intensity into the duration of illumination, and this has been shown to hold for the heliotropic curvatures of plants (Blaauw and Fröschl) and of hydroids (Loeb and Ewald). Furthermore, it has now been shown by Loeb and Wasteneys that the region in the spectrum most efficient in the production of heliotropic curvature is almost the same for hydroids (Eudendrium) and for oat seedlings. The investigators suggest that there are two types of photosensitive substance, one with a maximum sensitiveness (or absorption) in the yellowish-green, and the other with a maximum of sensitiveness in the blue. The first type is represented by visual purple, and a photosensitive substance of this type occurs in Chlamydomonas (often claimed as a plant), in Daphnia, and in many other organisms. The second type of photosensitive substance occurs in Euglena, in Eudendrium, and in many plants. Thus the distribution of the type of substance does not correspond to the boundaries between plants and animals.

(2) In another series of experiments Loeb inquires into the conditions which determine or prevent the entrance of the spermatozoon into the egg. It is well known that a fertilized egg is non-receptive to other spermatozoa. What is the nature of this block? It is not due to the changes underlying the development of the egg, for if the eggs of a sea-urchin are induced to develop by the methods of artificial parthenogenesis, a spermatozoon may still enter the egg or an individual blastomere. By simply altering the alkalinity of the sea-water Loeb can make a sea-urchin ovum receptive or non-receptive to the spermatozoon of a starfish; this depends on some rapid alteration of a physical property of the surface of the ovum. And the ingeniously worked-out experimental argument points to the conclusion that a block of this sort is induced when a spermatozoon fertilizes an egg.

But what of the more positive side of the question? There is a widespread belief that a spermatozoon shows a positive chemotropism for the appropriate ovum, but Loeb finds no proof of this in sea-urchins. The motility brings the spermatozoon fortuitously near the egg; the vibrations may assist in boring and in fixing the spermatozoon to the surface of the ovum until other forces, such as surface-tension, come into play. What is certain is that the spermatozoon cannot enter the egg unless physical conditions at the boundaries of egg, spermatozoon, and surrounding solution are right. It must be noted, however, that a sea-urchin spermatozoon becomes more active when it comes near an egg of its own species, and Loeb suggests that this activating effect of the egg upon spermatozoa, being most rapid as regards spermatozoa of its own species, is a means of preventing hybridization. In other words, the activating influence of the egg has some degree of selective specificity.

(3) In a third set of experiments Loeb tackles the problem of the degenerate condition of the eyes in some cave animals, such as fishes and salamanders. Though a few zoologists cling to the "natural" interpretation that the "blindness," which differs considerably in degree, is due to the hereditary accumulation of the results of disuse, the difficulties in the way of accepting this Lamarckian view are very serious. It has been assumed, therefore, that the blindness of some cave animals began as a germinal variation or mutation. But confidence in the legitimacy of this assumption has been lessened by the meagerness of our knowledge as to the occurrence of variations in the direction of optic degeneration. Very welcome, therefore, are Loeb's recent experiments which show that degeneracy of the eye can be readily induced by influences affecting the condition of the egg or the earliest stages of development. Thus, embryos with degenerate eyes can be produced by fertilizing the eggs of *Fundulus heteroclitus* with the spermatozoa of *Menidia*.

Since in these cases there is usually no circulation in the feeble embryos, the influence is suggested that the anomalous condition of the eye may be due to lack of circulation. Blind embryos of the pure breed of Fundulus may be produced by the addition of KCN to the sea-water; and a short exposure of the fertilized ova to temperatures between zero and 2 deg. Cent. results in abnormal embryos, a certain percentage of which will show degenerate eyes. It is interesting to learn that lack of light does not, in the case of Fundulus, influence the development of the eye. From Loeb's experiments it is not to be argued that the blindness of cave animals arose in any of the ways mentioned. What the experiments show is the legitimacy of the assumption that blindness may arise as a germinal variation or factorial mutation. And that is considerable gain.

(4) Other experiments deal with the influence of balanced and non-balanced salt solutions upon the osmotic pressure of the body liquids of Fundulus; with the functional importance of the ratio of concentration of antagonistic salts with univalent and bivalent cations; and with the membrane formation in the eggs of the sea-urchin.

(5) In an illuminating essay on the stimulation of growth, Loeb states his view that it may be inherent in an unfettered cell to grow and divide eternally in appropriate conditions, as is illustrated, indeed, by both Protozoa and Protophytes. This capacity may depend on the presence of synthetic ferments or "synthetic mechanisms" which are formed from the food taken up by the cells. But few cells show this capacity, and the question arises: What stimulates growth and what keeps the cell at rest? In most cases the unfertilized ovum soon dies, in spite of its potential immortality. If it is fertilized or treated with the methods of artificial parthenogenesis, it divides actively. The condition of rest or activity in this case depends, according to Loeb, upon the condition of the cortical layer of the egg and the alteration in the rate of oxidations connected with this condition. We do not know whether the resting of body-cells is determined by conditions identical with those determining rest in the egg.

"We know, however, that specific substances circulating in the blood can induce certain resting cells in the body to grow, and that these substances differ apparently for different types of cells. It may be that in the body substances antagonistic to these may enforce the inactivity of the cells."

(6) In a vigorous and characteristic paper entitled "Mechanistic Science and Metaphysical Romance," Loeb argues that the demonstration of the reality of molecules and the counting of their number in a given mass of matter "puts science for a long time, and probably irrevocably, on a mechanistic basis. It marks, perhaps, the greatest epoch in the history of the theory of cognition. It enables and compels us to define the task of science differently from Kirchhoff, Mach, and Ostwald. We may say it is the task of science to visualize completely and correctly the phenomena of nature, of which our senses give us only very fragmentary and disconnected perceptions. We must try to visualize the numerous hidden processes and conditions connecting the disconnected phenomena we perceive." We cannot argue the question here, but we must be allowed to enter our dissent from Loeb's conclusion that the activities, development, and evolution of organisms can be adequately and exhaustively described in mechanical terms, or in chemico-physical terms (which are regarded by many as ideally mechanical). We are convinced that in living creatures new aspects of reality have emerged which transcend mechanistic formulation. We are inclined to think that further study of the metaphysics which this consummately ingenious experimenter slangs so vigorously might render him less confident in the stability of his mechanistic system. We yield to none in our admiration of his illuminating scientific achievements, but we cannot agree with his philosophy.—*J. A. T. in Nature.*

A Memorial to the Engine Room Staff

A memorial commemorating the self-sacrifice of the engine-room staff of engineers, electricians, boilermakers and others who lost their lives at sea in the path of duty now occupies a prominent place at the Prince's Pier Head, Liverpool. It is of gray granite, 48 feet high, and surrounded by a raised border of grass, about 40 feet in diameter, with a granite kerb. The memorial is the work of Sir William Goscombe John, R.A., the motive being the battle of the elements.

Automobiles in the Great War—II*

Types of Cars Used and Technical Details Considered in the Light of Experience

By W. F. Bradley†

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2117, page 67, July 29, 1916

METAL WHEELS BEING ADOPTED.

ONE of the most important developments of the war is the adoption of the all-metal in place of the wood wheel. Although the wood wheel may continue in use for some years on commercial trucks, and possibly will not be abandoned for touring car purposes, it is already doomed for army trucks. The primary objection brought against the wood wheel is that, even if well made of good material in the first instance, it requires attention from time to time to keep it in proper condition. This defect is most apparent when trucks have to remain out of doors day and night, indeed on all occasions except when in the repair shop. Another objection is that if the vehicle catches fire—and the enemy's guns are constantly on the search for convoys working back of the lines—the wheels are liable to be destroyed and it becomes a difficult matter, if not an impossibility, to get the truck away. With metal wheels it is nearly always possible, when the fire has burned itself out, to tow the vehicle home. Apart from the body, it is surprising how little a burned-out truck will suffer in its essential organs.

Practically no army trucks are now being built in Europe with wood wheels. All the Austin and other trucks supplied to the Royal Naval Air Service for use in France in a short time had their wood wheels changed for those of the steel disk type. Generally, when replacements become necessary cast-steel or disk wheels are substituted for wood. A small number of American trucks have been changed in this way.

For trucks of 3½-ton capacity and upward the cast-steel wheel of the spoke variety is extensively employed by French and Italian makers, and also by the British. The latter, however, are also partisans of the disk type. For the lighter units, such as light trucks on twin pneumatic tires and motor ambulances, the steel-disk wheel has made a remarkable jump into favor. These pneumatic-shod wheels can be detached by removing 4 to 6 nuts. Incidentally, 4 studs and nuts, adopted by some makers, are considered an insufficient attachment. Six should be a minimum. The detachable wire-spoke wheel has not been give a more extended application, although it has held its own on touring cars used by staff officers.

RUBBER TIRES USED ON ALL WHEELS.

Not many years ago the French military authorities were inclined to favor the use of steel tires, particularly on the driving wheels. The results were not satisfactory, the initial economy being more than offset by the greater cost of upkeep and the difficulty of operating the vehicles on greasy granite-paved roads. The war has proved the necessity of using rubber on all trucks and on all wheels. Block tires, for which many claims were made at one time, have not proved satisfactory. The alleged advantage of being able to replace a block if one gave out has not been substantiated. One reason is that the new block always has a greater thickness than the worn unit it has to replace.

All kinds of tire troubles have developed and moreover kinds unknown under peace conditions. Mileage has dropped very low and many trucks in the north of France are not averaging more than 1,500 miles on a set of band tires. On some of the heavy gun cars 800 miles is considered a fair average and 1,500 miles excellent service. These, however, are special vehicles having a load of 7 tons and more, obliged to operate in a fire-swept zone not negotiated by any vehicles other than the light 2-wheeler carts of the Army Service Corps. One section of Pierce-Arrow 5-ton trucks doing ordinary transport service in France averaged 5,000 miles on a set of tires, but 4,000 miles can be considered a fair average.

Tires do not perish principally by having their tread worn down. They chip away laterally; they come away from their base, sometimes for short distances, sometimes for their entire circumference; and generally they wear unevenly. On all the cambered roads of France the inner one of dual tires carries the greater portion of the load and, of course, wears down before the outer one. It is worth suggesting that some means of equalizing wear be devised; a detachable and reversible wheel, separate from the bearing housing, would make it possible to get the full life out of a pair of bands, instead of having to scrap both when only one is worn down.

An engineer officer connected with one of the Pierce-Arrow convoys, who was troubled with this uneven wear of tires, often followed behind the trucks on a low sidecar. The road consisted of a centrally paved strip, 10 feet wide, with the outer strips composed of a mixture of mud and more or less broken stone. When passing other vehicles it was necessary to run with the right-hand wheels in the mud, the left-hand side of the body then being a foot higher than the right-hand side. Under such conditions it was possible to see daylight under the outer of the dual tires, showing that the wear was all on the tread of the inner tire. It was also noticed that the standard equipment for front wheel tires was insufficient for the rough roads near the front. When dropping into shell holes and bumping over obstructions it was common to see chunks of rubber torn out of front tires, causing them to be withdrawn from service more frequently than the rear ones.

The experiment was therefore made of fitting wider front tires and narrower rear ones. In the place of the original set of 36 by 5 front and 40 by 6 dual rear, the engineer had fitted 36 by 6 front and 40 by 5 dual rear. This change was satisfactory; the mileage being greater and the cost less. There was less tendency for the front wheels to bog and drivers said that road shocks at the steering wheel were less. The angle of wear for the inner tire was reduced, the outer one taking the load sooner owing to the narrow tread. The tendency to skid was also considerably reduced.

BODY SIZES AND CONSTRUCTION.

The body dimensions fixed for French trucks and confirmed by the war are a platform of 138 by 67 inches with removable sides 24 inches high. The driver's seat must be 55 inches wide. The hoops carrying the canvas top have to be of sufficient strength for each of them to carry a load of 660 pounds, the central hoop receiving 1,300 pounds. This allows wounded men on stretchers to be brought to the rear when trucks are returning after delivering supplies and was done extensively during the series of battles for the possession of Verdun. Owing to this specification the hoops are generally of steel and are fitted with rings. Many of the American trucks supplied to the Allied armies had a prairie schooner type of body, with a single top covering the load and the driver. This was a mistake as the driver was left without protection when the nature of the load necessitated the removal of the top. Also with no division behind them, the men on the front seat were in the position of a person in the mouth of a drafty alley. It is essential that the two tops be independent, and that there be a vertical division just back of the driver's seat. Drivers need much more protection than is given on the standard commercial vehicle. This protection has not been given by American makers. The drivers have therefore provided it themselves, sometimes with peculiar results. The British have a preference for a permanent driver's cab with side doors and canvas extension above the dash, so that in bad weather only the upper portion of the driver's head is exposed. The roof of the cab carries a rifle rack. This arrangement is satisfactory, particularly for English weather conditions.

It is a primary condition that the rear wheels must not break the uniformity of the body platform. On this account the body is raised a little above the frame members. Advantage should be taken of the lateral overhang of the body to fit stout lockers alongside the frame members. This has been done in many cases to provide storage space for the regulation spares the truck must carry. Few makers appear to have realized, however, that a couple of men having to live and eat aboard the truck also need spares, and that no space is provided for their storage. This could easily be remedied by fixing additional lockers alongside. The construction of these boxes should be strong and door hinges should be at the top—that is the door should open upward.

Although special vehicles are provided for the rapid transportation of troops, all trucks are liable to be called upon for this work on occasions. It is thus desirable that the body should be so designed that it can receive either a couple of longitudinal seats down the center and about 6 inches apart or transverse seats. The accommodation required is of the most primitive nature, and the fittings should not interfere in any way with the normal service of the truck. The brightly tinted yellow or sandstone canvas tops supplied with many American trucks are a danger under European war conditions. The correct tint is gray, or blue-gray, or better still variegated with blue-gray as the dominant note.

USES OF FOUR-WHEEL DRIVEN TRACTORS.

Practically all the ordinary transportation of the Allied armies is done by rear-drive trucks. The 4-wheel driver is doing special work and does not usually come into competition with the 2-wheel driver. In other words, the 2-wheel driven truck is the most satisfactory and the most economical type for the general transportation of food, ammunition and men. The 4-wheel driver first came into use 5 or 6 years ago when the French army sought to abolish the use of horses in the haulage of its heavy field pieces. For this work it was impossible to consider the ordinary truck, for the artillery rarely operates along main roads, and in the majority of cases has to work on no roads at all. What was required, therefore, was a tractor capable of hauling the guns to all positions open to horse teams, and of doing the work faster than it could be done by horses. The abolition of horses for haulage of the guns also implied the abolition of horses for the transportation of munitions; thus the tractors had to be capable of hauling trailers loaded with shells to any position that might be taken by the guns.

The problem has been a difficult one, for it was not by any means sufficient to duplicate the points of application of the power in order to obtain a vehicle that could travel over any kind of country and mount any kind of obstacle. The difficulties met by ordinary trucks when obliged to abandon main roads also had to be faced by the 4-wheeled driven tractors. The difference is that the 4-wheeler's real work begins when the going is such that the ordinary truck would have ceased to be of any use. A large amount of experience has been acquired in the use of chains, paddles and caterpillar bands for the road wheels in order to allow these tractors to operate under all kinds of cross-country conditions. The results, however, have been sufficiently satisfactory to justify the belief that the horse has ceased to be necessary to the heavy artillery batteries.

TRACTORS DEVELOPED BY FRENCH ARMY.

The French army has developed two different types of 4-wheel driven tractors: a heavy tractor capable of hauling not less than 12 tons, generally on two trailers; and a light tractor hauling a minimum of 8 tons. The unloaded weight of the heavy tractor is limited to 5 1-3 tons, and the light tractor must not scale more than 3½ tons; these weights comprising the complete vehicle, 2 drivers, gasoline, oil, tools and spares. Although some 6-cylinder engines were used for this work in the early stages, at present 4-cylinder engines are employed exclusively. Every tractor is fitted with a power-driven winch or capstan. This is absolutely essential, war experience having shown that even a 4-wheel driver cannot work successfully across country without this auxiliary. As a general rule the winch placed horizontally across the front of the frame has been the most successful type. Towing hooks are fitted front and rear, an artillery-type elastic coupling is provided at the rear, a powerful sprag or ratchet is fitted and the tractors have equal size dual tires front and rear. The use of these tractors has been confined largely to the haulage of 120 and 155-millimeter field guns, which is heavy artillery that must, nevertheless, possess a reasonable amount of mobility.

The 4-wheel driven tractor has not been used to any great extent in the haulage of the 75 millimeter field piece. Nevertheless, a certain number of the 75-millimeter batteries have been motorized. The weight of this gun, without its carriage, is only 1,014 pounds. Thus it can easily be carried on a chassis designed for a 3½-ton load. The problem to be solved was a system of quick-acting jacks that would take all the weight off the springs when the gun went into action and give the same rigidity as with the ordinary gun carriage. For these automobile guns the authorities have selected De Dion Bouton and Schneider 3½-ton chassis similar in general design. The engine is a 4-cylinder of roughly 4¼ by

*Paper to be presented at Semi-Annual Meeting of Automobile Engineers.

†European correspondent, *Class Journal*.

6-inch bore and stroke; the gearbox provides 4 speeds; and final drive is by internal gears. These batteries have been extensively and successfully employed for anti-aircraft work. The ammunition wagons are of the same general design as the gun-carrying chassis. Unlike the ordinary trucks the hood is armor plated. The gasoline tank is placed at the rear inside a steel box without a top. This gives it adequate protection against bullets and shell splinters.

An entirely distinct class of work is the use of automobile tractors for the haulage of heavy artillery—14, 15 and 16-inch guns. For this class of slow-speed heavy haulage, steam has been abandoned in favor of the internal-combustion engine. Even the British, who have always shown a partiality toward steam, have adopted gasoline tractors for the haulage of heavy guns. Although varying considerably in details of design, these tractors are all on the same general lines. They embody little of the automobile type chassis. In one particular case a pure traction-engine chassis, made by a steam traction-engine manufacturer, is employed and is fitted with a 6-cylinder Knight engine of about 6 by 6½-inch bore and stroke. The engine operates the large diameter metal road wheels through internal gearing and in addition drives a powerful winding drum. The tractors haul loads of 25 to 30 tons distributed over two or three trailers. Their rate of travel is 3 to 4 m. p. h.

For this work the caterpillar tractor is being used to a moderate extent by all the Allied armies. Except for agricultural purposes Europe had paid little attention to the caterpillar tractor before the war. Thus the machines now used by the armies are practically all of American origin. On certain occasions when the enemy's lines have been broken by heavy artillery fire followed by well-ordered infantry attacks, it has been found difficult to make this temporary success a permanent advance by reason of the slow rate at which the supporting artillery has been brought up over the broken country. It is under such conditions that the caterpillar tractor can be used to best advantage. There is no kind of country over which it cannot move, and it is capable of bringing up guns more quickly than they can be hauled by horses.

The necessity has been shown for specially trained crews for the handling of 4-wheel driven tractors and of heavy artillery tractors and caterpillars. An ordinary automobile driver is not sufficiently experienced. The men, and the officers in command of them, should know immediately what kind of country can be traversed with and without chains and paddles on the wheels; what hills can be climbed with the full number of trailers; where to drop the load; and where and how to put the winch in operation.

The adoption of motor traction for a heavy howitzer battery means that the entire work of the battery is performed by mechanical traction. Thus a battery with 45 tractors will have attached to it about 40 5-ton trucks and 20 3-ton trucks for bringing up ammunition and supplies, as well as about 15 cars for repair service.

WORK OF ARMORED CARS.

Practically everything on wheels capable of carrying a machine gun has been fitted up for service at some time or other and termed an armored car. Nearly two years of fighting is a sufficient length of time to allow many errors to be corrected and to give plenty of accurate information on what armored cars can and cannot do. Even now, when the unsuitable types have been eliminated there are several varieties of armored cars. At one end of the scale are the motorcycle and sidecar carrying a machine gun, and at the other end the heavy truck, weighing about 12 tons, and carrying 4 machine guns and 1 field piece.

It should be pointed out, however, that an exaggerated importance has been given to the armored car. In the present stage of war on the Western front, with men in trenches 10 feet below the ground and in dug-outs 20 feet below the earth's surface, there is not much opportunity for a scouting automobile to show its merit. But before this underground warfare was adopted armored cars were important, and they will doubtless again be important when open fighting is resumed.

The most suitable type of machine has been found to be a powerful touring-car type of chassis with a 4-cylinder engine of approximately 4 by 6-inch bore and stroke, or its equivalent. The single compartment body is built up of steel plates, generally 0.3 inch thick, capable of resisting rifle fire at close range. The plating extends over the engine and the radiator, with louvres to allow a sufficient draft of air for cooling purposes. Steel disk wheels are fitted, with twin pneumatic tires at the rear and fenders designed to deflect bullets without interfering with the accessibility of the wheels. Double steering, although a decided advantage has not been adopted in the majority of cases. No ordinary chassis is built to steer from both ends, and rather than undertake considerable work the cars have been sent out with ordinary steering. In practice the double steering is never required except at rare intervals and for short periods; when it is needed, however, it may be needed badly. These cars usually carry one or two machine guns in a turret, or sometimes a machine gun and a cannon. A powerful wire cutter is an important adjunct.

TRAILERS BEHIND ALL KINDS OF CARS.

It is worth noting that the war has brought about an extensive use of trailers. Their first application was in the automobile service, where loads are bulky and light. Their use has been extended in this service and has also been adopted by other branches of the army. Naturally the 4-wheel driven tractor has tended toward a considerable increase in the use of trailers, but these are vehicles originally designed for operating with trailers. The trailers are now being attached behind all kinds of automobiles, which, it was originally thought, would never have to receive them. Thus 3½-ton trucks working with bulky loads are being made more efficient by the addition of trailers. A large number of light trucks, of ¾ and 1-ton capacity, mounted on pneumatic tires, are fitted with the special army type elastic coupling at the rear and will take one or two 2-wheel pneumatic-tired trailers. These are extensively used for the transportation of men working in the rear of the lines. For instance, at a big aviation depot employing 500 men, who have to work 5 miles from their billets, these light tractors and trailers are used to take men backward and forward morning, noon and night. The machines are not kept specially for this purpose, but are used on general haulage work around the depot. The trailers are merely 2-wheel floats with canvas tops on detachable hoops; the front is closed and entrance is at the rear; there are 2 longitudinal seats. In a few minutes the trailers can be stripped to mere platform bodies suitable for carrying aeroplane wings or a complete aeroplane. As a speed of 35 m. p. h. can be maintained on good roads, these outfits are valuable, in case of necessity, for the quick transportation of troops to threatened points. Many of the smaller munition factories not having sufficient work to justify the purchase of a truck, are using ordinary touring cars with a trailer attached.

WAR STANDARDIZATION LESSONS.

Innumerable arguments can be found in the war zone in favor of standardization. The military tendency the world over is toward uniformity, and attempts will doubtless again be made to standardize design. This is a tendency that should be energetically opposed, for no single vehicle can monopolize the good features of automobile design. As already pointed out, the attempt to impose on manufacturers a purely military type is doomed to failure. No army can maintain in peace all the trucks it will require for war conditions. Any military type that can be developed is bound to be swamped by the thousands of purely commercial models that will have to be enrolled when the nation goes to war.

Certain features can be insisted on—and indeed are required in Europe at the present time—without handicapping the designer or making it difficult for him to adopt improvements as they are suggested by experience. The features that should be uniform are: size and style of bodies; wheels and tires (in France these have now been reduced to one size); magneto bases and couplings; carbureter flanges; towing hooks; turning radius; clearances; driving chains; threads for all bolts and nuts; and control.

All these features can be adopted, for trucks of a given capacity, without interfering in any way with the scope of the designer and without arresting progress. Although the army type body may not be suitable for all classes of business, it is an easy matter to make the one adopted interchangeable with it. But it is in the repair shops that the real lack of standardization is felt. The repair staffs that have to handle every kind of vehicle from the automobile factories of the whole world, can be excused for believing that not even the fringe of this problem has been touched. Not only does there appear to be an entire lack of uniformity between one firm and another, but even the product from individual factories is not sufficiently standardized. The military authorities have every reason to encourage the movement toward standardization in automobile engineering.

UNIFORM NOMENCLATURE NEEDED.

The archaic system of naming automobile parts is another difficulty that ought to be removed. The confusion is so great that in the big stores, where French, American, English and Italian spares are given out, it has been necessary to adopt a new international code. It is one of the curiosities of the war that France should be interested as much as America in the standardization of the technical terms of the American automobile industry.

German Chemical Industries Combine

A RECENT issue of *The Engineer*, London, gives the following details of a new combination that has been formed by the manufacturers of chemicals in Germany, in view of the competition they anticipate after the war.

With the exception of the chemical works styled Griesheim-Elektron, which were somewhat late in joining the large new combine of the chemical industries of Germany, all the large concerns have now held their general meetings and sanctioned the new agreement. This agreement includes the Hochster Dye Works, Messrs. Leopold Cassella & Co., Kalle & Co., Ltd, the Badische Anilin and Soda Works, the dye-works of Bayer & Co., the company for the manufacture of aniline dyes at Berlin-Trepton, the chemical works of Weiler-ter Meer, and the chemical works of Griesheim-Elektron. The arrangement provides for a closer co-operation between kindred concerns within the same industry than has ever before been known in Germany. The reasons for the combine are stated to be the uncertainty of the future, the increasing competition on the part of neutral and hostile countries, and a desire to bear jointly the risks connected with foreign affairs. At the same time the separate concerns retain their independence and freedom of action, while they are to afford each other all possible support and communicate to each other all data acquired in the matter of manufacture, etc. The agreement covers a period of fifty years from January 1st, 1916, except the Griesheim-Elektron concern, for which the agreement will operate on January 1st, 1917.

The most interesting feature of the affair is that all the profits are to be pooled, the profits being arrived at according to uniform rules, and divided between the different participating concerns according to a fixed percentage. In the case of some of the firms the entire production does not contribute to the profits of the pool, and of others there are some special exceptions, which only later on, according to fixed periods, will accrue to the pool. As regards the Hochster Dye Works, for instance, the special profits on calcium carbide, nitrolim, and certain products derived from these commodities are reserved; for the old combined concerns, the Badische Anilin Company, the Bayer Company, and the Trepton Company, the profits on the new departure at Ludwigshafen in the matter of synthetic ammonia and its products are exempt. The fixing of the participation percentage has, of course, been a difficult task, but a solution was found by the three largest works, the Hochster Dye Works, the Badische Anilin and Soda Company, and the dye works of Bayer & Co., each obtaining 24.82 per cent of the aggregate pooled profits for the first ten years, and after the expiration of that time 25.02 per cent. These three works will thus during the first ten years take 74.46 per cent, and after that period 75.06 per cent of the aggregate profits of the combine, leaving respectively 25.54 and 24.94 per cent. The Berlin-Trepton Company for aniline dyes has had apportioned to it 8.08 per cent for the first ten years and 8.14 per cent after the lapse of that time. In the old triple combine, Ludwigshafen-Bayer-Trepton, the latter participated with 14 per cent, and the two others with 43 per cent each. So as to bring the Hochster Company on the same footing as regards percentage, the capital of this company has been raised to the same amount as that of Ludwigshafen and Bayer by an increase of 4,000,000 marks, issued at a premium of 100 per cent, which price is materially below that ruling in the open market. A further transfer of capital has taken place by the shares of Kalle & Co., in Biebrich, formerly held by the Cassella firm, having passed into the possession of the Hochster concern, which now holds the entire share capital of 6,000,000 marks of the Kalle concern.

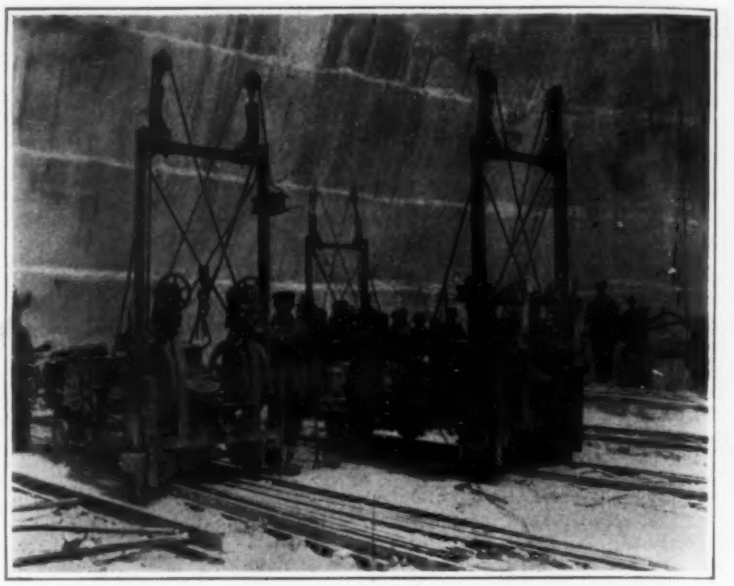
The relative position of the works of the combine as regards share of profits is as follows:

	First Ten Years. Per Cent.	Afterward Per Cent.
Hochster Dye Works	24.82	25.02
Baden Anilin Company	24.8	25.02
Bayer, Leverkusen	24.82	25.02
Leopold Cassella Company (about)	10.00	....
Anilin Company, Trepton	8.08	8.14
Griesheim Works and Weiler-ter Meer Works (about)	7.50	?

With reference to the manner in which the profits available for the last two companies are to be divided, nothing definite has been stated, but it has been surmised that 6 per cent will go to the Griesheim-Elektron Company and 1½ per cent to the Weiler-ter Meer concern.

It may be mentioned in this connection that the Badische Anilin and Soda Works have just declared a dividend of 20 per cent for last year, the Bayer Works at Leverkusen a dividend likewise of 20 per cent, against 19 per cent for 1914, and the Weiler-ter Meer Works one of 12 per cent.

Six-foot circular saw equipped with a 25 horse-power driving motor and a 3 horse power motor for operating the feed mechanism.



Group of double-lever channelers, each driven by a direct-current railway type motor.

An Electrically Operated Marble Quarry

Many Different Machines at Widely Scattered Points Demonstrate the Advantages of This Kind of Power

By Frank C. Perkins

In view of the wide application of electricity in practically every branch of industrial activity, it is not surprising to find this versatile form of motive power at work in the modern quarry. Many of the tasks heretofore performed by manual labor in the quarries are now performed by electrically-driven machines, and invariably the resultant product is not only less expensive, but it is also of a more uniform and better quality.

In the accompanying illustrations appear several of the machines employed in one of the leading Vermont quarries. The first of these shows a six-foot circular saw employed in cutting and trimming marble slabs, which is provided with two motors; one, a 25 horse-power motor, rotates the huge saw; the other, a 3 horse-power unit, drives the feeding mechanism. The periphery of the saw has inset diamond cutting tools, permitting of very rapid sawing. However, this machine is not intended for work ordinarily performed by the gang saws or rubbing beds.

A most interesting machine is the electric carborundum machine employed for cutting moldings in pieces of marble. The bed plate has a slow reciprocating travel similar to that of a planer. The adjustable grinding elements are carborundum wheels of various sizes and shapes. By functions of these wheels flutings and fillets of various sizes can be produced, resulting in elaborate decorative moldings. As in the instance of the circular saw, the machine is independently driven; a 20 horse-power motor driving both tools and bed plate.

There are several hundred pneumatic hand tools used in the stone-cutting shops, to which air is supplied at pressures of from 50 to 60 pounds by motor-driven compressors. These, in the broader sense, also may be regarded as electrically-operated equipment.

The handling of stone is expedited by overhead electric traveling cranes of standard design.

In the second view appears a group of double-lever channelers which are provided with a gang of long chisels set on either side of a strong framework and actuated through gearing by a 12 horse-power railway type motor. The vertical, reciprocating motion of the chisel gangs, combined with the slow forward movement of the machines, forms narrow channels or slots of the desired length and depth, usually at right angles to the "rift" or natural cleavage line of the marble strata, and cross channels in order to secure blocks of the desired size. Although the motors employed in these machines are unavoidably and continuously subjected to a considerable amount of vibration when the channelers are in action since they are mounted directly on the channelers, still, in spite of the severe conditions, the original equipments of 20 years ago are to-day in regular use on flat cutting and operating with unimpaired efficiency after an active service of nearly two decades.

Because of the varied arrangement encountered in marble strata, it is frequently necessary to operate channelers at various angles to the horizontal and, as may be noticed in the illustration, since the mechanical design of the machines shown in the second view limits their effective use to surfaces which are practically level, another form of machine shown in the third illustration is utilized where both flat and slope channeling are required. The last named machine is equipped with only one chisel gang, which is given a positive reciprocating motion by means of compressed air. This in turn is supplied in a closed circuit by a motor-driven compressor: the entire outfit comprises a self-contained unit. The operator can secure all necessary speed adjustments through the motor controller.

There are in all about 100 channelers used in the Vermont quarries, including some two dozen of the old double-lever type, which are driven by direct current motors as compared to the electro-pneumatic machines which are uniformly equipped with 12 horse-power induction motors. The latter motors have phase wound rotors and external resistances connected through slip rings, making them especially adaptable to conditions requiring frequent starting under load with a relatively low current consumption.

In addition to the channeling process, the bottom of the block of marble is perforated by means of drills. The holes are usually driven either along or parallel to the "rift" or natural cleavage line, thereby rendering possible the loosening of the block by means of levers or wedges. No blasting is required as the actual work of quarrying marble is performed entirely by machinery. There are over 70 electro-pneumatic drills employed for perforating the marble blocks. These drills operate on the same principle as the electro-pneumatic channelers, although there is a slight variation in their construction in that the drill proper and the motor-driven air compressor are separate, transportable units, connected only by flexible tubing. The load conditions are not severe and the compressor is geared direct to a two-speed 5½ horse-power induction motor.

While the greater part of the quarries are open workings from which the detached blocks of marble are removed with the aid of derrick hoists, some of them extend for a considerable distance under ground and employ heavy pillar supports for the roof or hanging walls. In some respects the conditions in such quarries entail work similar to that encountered in mining. The West Rutland quarry offers a striking example of quarrying along mining lines. Here the workings have been carried to a depth of about 300 feet and the opening at that level exceeds 2,000 feet in length. Electric lighting is required to illuminate the workings and an electric locomotive is used to haul the blocks of marble from the working face to the base of a slope hoist, which in turn brings them to the surface. It may be added that to provide suitable working conditions, it has been found necessary to employ forced ventilation in the underground galleries of the West Rutland quarry. This is amply provided for by a six-foot fan located on the surface and driven by a 40 horse-power induction motor.

Water in varying quantities is frequently encountered in quarrying. Furthermore, as the quarry openings are practically unprotected, a certain amount of surface drainage and seepage must also be provided for. The pumping sets used for dewatering the quarries include both reciprocating and centrifugal types, driven by induction motors. Small portable pumps driven by 2 horse-power motors are available, as a rule, for temporary use. For heavier work stationary units are used, in which case the motor is of about 35 horse-power rating which is ample since in no instance does the operating head exceed 350 feet and the load demand is not heavy.

In the West Rutland quarry there are at the present time in service a total of about 570 motors which range in capacity from 2 to 250 horse-power, with an aggregate rating of approximately 14,000 horse-power. Direct current units are in many cases applied to hoists, cranes and locomotives, and constitute about 25 per cent of the total motor equipment; the remainder being polyphase induction motors operating at 220, 440 or 2,300 volts on three-phase 60-cycle circuits. Fully 65 electrically-operated rubbing beds are at work in the different shops. The older installations consist of groups of five or six machines driven through counter-shafting by 50 horse-power motors. The individual drive system is now largely used and the more recent additions to the shop machinery provide a 25 horse-power motor belt-connected to each pair of rubbing beds.

The electric current is supplied to the various plants from four hydro-electric stations having a total capacity of 5,525 kilowatts and two steam stations having an output of 1,250 kilowatts. Distribution is made through eleven substations, over transmission lines aggregating more than seventy miles in length. The hydro-electric stations are all located on Otter Creek, a small stream which rises in Bennington County, Vermont, flows through Rutland and Addison counties, and enters Lake Champlain near Vergennes.

The electric system is particularly convenient for quarry work, as it is unaffected by the temperature changes, which must always be considered with steam or air lines, and the laying of additional wire or cable to supply current to new machinery or to meet changes of location of any existing machine can be safely, easily and rapidly accomplished without interfering in any way with the operation of the remainder of the quarry equipment.

Electro-pneumatic channeler driven by a 12 horse-power induction motor which actuates an air compressor.

Marble rubbing beds in finishing shops, on which slabs of marble are ground smooth and polished.

Materials Used in Case Hardening*

By R. A. Millholland

Of all the forms of heat treating, no doubt case hardening is the most extensively employed. It is merely an application of the old cementation process of making steel from iron. Of course, improvements have been made over the original methods, both in the process and in the materials involved. There are two prime requisites that case hardening fulfills more efficiently than any other process known to modern mechanical science, namely, a very hard non-wearing surface and tough malleable core that is capable of absorbing an enormous amount of vibration without serious difficulty.

The application of the process of case hardening is too extensive for exhaustive enumeration in this limited space. Generally speaking, short shafts, pins, bolts, collars, thrust rings, screws, bearings, spindles, gears, ratchets, clutch dogs, or any machine parts that are made of steel and are subject to wear, can be advantageously case hardened at a very small cost. The writer has in mind a company that makes a practice of case hardening all the steel parts of its tools and jigs used in the manufacture of automobiles. The maintenance on these tools is surprisingly low. Locating lugs and centering blocks do not wear away on the edges and become inaccurate. Practically the only replacement that is done on the tools at all is of drill bushings and boring bar guides. The locking devices, set screws, and clamps showed no sign of wear after months of constant production. One small cotter pin hole has had 40,000 shackle bolts pass through it and it is still as accurate as micrometers can measure. The same jig was replaced three times in drilling 20,000 holes before the case-hardened jig was made. No change in design was made; only the case-hardened feature was added. Any steel surface, whether a bearing one or not, that is liable to be nicked or marred by rough handling can be made practically indestructible by case hardening. The advantage of the process of case hardening low-carbon steel in place of using high-carbon tool steel is obvious in many instances, yet it must be clearly understood that case hardening is not a cure-all shin plaster to be used indiscriminately for any and all purposes. Each firm must learn largely from experience what can be case hardened to advantage.

Let us first have clearly in mind what is meant by the term case hardening, and the cementation process. We must hark back to the days when the art of making steel was new—how far back no one really knows, but the names of Damascus and Toledo are familiar to all readers of history. Were you to ask one of these readers what was the most striking thing that he remembered about these two ancient cities, no doubt the answer would be: "The swords of Damascus and blades of Toledo." Without a doubt both of these famous steels were made by the cementation process with some improvements, the secrets of which died with the prestige of the cities.

A fine grade of wrought iron was the base upon which the cementation process was founded. Flat bars of iron were placed in furnaces packed in layers of charcoal and subjected to a temperature in the range of 1,400 to 1,650 deg. Fahr. The carbon in the charcoal was dissolved by the iron and when carbon had penetrated the steel and thoroughly saturated it, the cementation was considered complete and the bars were removed and "stack welded" one upon the other to a homogeneity that has been the envy of succeeding generations of steel craftsmen. The ancients realized the value of "working" their steels and the results secured were remarkable. The writer does not want to be misunderstood, however, causing some to believe that ancients could produce better steel than our latest modern manufacturers do. The ancients had nothing to surpass or even equal the chrome-vanadium steel of to-day.

The process of case hardening, then, is nothing but the proper regulation of the cementation or infusion process, as some see fit to call it. The old method of using charcoal as a means of injecting, or infusing, the carbon into the iron is slow and costly. Many newer and better materials have been discovered which are far superior to the old charcoal process.

It was discovered some years ago that the presence of nitrogen in the carbonizing material materially increased the speed of penetration or infusion of carbon into the surface of the iron. It was found after investigation that nearly all of the numerous patented carbonizing compounds have only two really essential elements in them, and despite the claims of the virtues of their respective products, carbon and nitrogen still remain the two major elements involved in case hardening. It is of little or no consequence to the practical man, whether the carbon penetrates the steel in a gaseous or solid state. Let the ultra-scientific theorize on that subject and meanwhile let us consider the natural carbonizers and their faults and virtues. Among the natural carbonizers, those most extensively used are granulated bone, charred hoofs and leather, beet sugar pulp and crude raw sugar. Granulated bone is no doubt the most widely used of all carbonizers and while it has some almost unforgivable evils, its availableness and price make it a universally used carbonizer. Its one and only great drawback is the high phosphorus content which has a noticeable effect on the toughness of the case-hardened area, making it brittle and prone to chip or flake off in service. However, after bone has once been burnt over and still contains a high percentage of carbon, the danger from the phosphorus decreases with the number of times the bone is used. I should say that 36 hours of actual carbonizing heat is all that bone will stand and give any kind of results at all. If the bone is properly fortified after each heat, it can be used repeatedly, and grows better in carbonizing quality after each fortification. Highly uniform results can be obtained by uniform methods in fortifying the "spent" bone. By fortifying I mean restoring the carbonizing power of the bone. Bone is made up largely of lime which really forms the body or structure of the bone and is in evidence when after repeated heatings small bits of chalky white substance are found in the mass of burnt-over bone, indicating that the bone is almost spent or burnt out. The writer has developed a method of his own regarding this process of refortifying spent bone and will gladly furnish any fellow craftsman with more particular details than this limited space will permit.

Charred hoofs and leather when mixed with hickory charcoal make a very good carbonizer, but the mixture is very uncertain and where uniform results are required the fortified bone is best and costs much less. Beet sugar pulp is obtainable from any sugar refinery at a surprisingly low cost, and in the writer's estimation has no rival for case hardening nuts and screws as the work comes from the carbonizing pots without any adhering dust particles and fused bits of metal that we often find in the charred leather. Five hours is the longest heat that beet sugar pulp will stand before it is spent and nothing is left but a light flaky dust in the cans. The shrinkage of the pulp is at least 30 per cent. Beet sugar pulp is high in volatile carbonizing gases and for that reason the carbonizing retorts must be thoroughly gas tight to secure the depth of case in the parts undergoing case hardening.

Now let us consider the artificial, or rather the manufactured, case-hardening compounds. Some are patented, but many are not, and I shall describe several different brands. Each manufacturer of carbonizing compound quite naturally claims his to be the best, and I have pamphlets and booklets on my desk that show clearly and quite convincingly, I confess, that the particular brand of carbonizer exploited in the pamphlet is the best obtainable. I might truthfully say that I have not run across any real bold frauds in this particular line, at least not within the last six years, and any of the better known products are safe and reliable carbonizers to use, that is, disregarding the economical side of the question. I have found all of the present carbonizing compounds put out by the manufacturers to be very expensive, and they all lose their body and disintegrate into fine dust and do not respond to fortifying as well as the natural bone does. For very fine work I strongly recommend the use of a manufactured carbonizer because the results obtained are undoubtedly the superior of bone carbonizer, but for ordinary purposes bone is quite satisfactory.

The reason for this discrimination between ordinary work and delicate case hardening is based on scientific principles. The writer has found through his own experience that a carbon content in the case of 0.85 per cent gives the very best results for a hard, stiff case that will neither wear away easily nor chip off under a slight blow. Of course, it is quite impossible to secure such a distinctly theoretical carbon content in your case, but anywhere from 0.85 to 1 per cent carbon in the case will give remarkable results if properly heat treated. A closer adherence to this range is secured by using the balanced compounds of the carbonizer manufacturers rather than by indiscriminately using natural carbonizers. However, for the most part, the fortified bone will give very good results and it is much more economical.

*The Iron Age.

The Hudson Bay Railway

Statistics in regard to the Hudson Bay Railway tabulated by Canadian Government officials, show that there had been expended on account of this railway to January last £3,093,060. There are 378 miles of grading completed, and steel had been laid for 242 miles. It is expected that steel will be laid to Port Nelson early in 1917, and that the harbor will be ready for traffic, though incomplete, about the time the railway is ready for operation.

Rapid Nickel Plating*

Investigations With a View of Improving Present Methods

By Oliver P. Watt, University of Wisconsin

During the greater part of the half century that nickel plating has been practised, platers were content to follow in the footsteps of their forefathers and deposit nickel at the snail's pace of three to five amperes per square foot. A few years ago "rapid nickel salts," claimed to permit of nickeling at two to three times the usual rate, were imported from Europe. These proved to be only mixtures capable of yielding more concentrated solutions than that enemy of progress, the "double sulphate," which for so long has masqueraded as the plater's friend. The American plater soon learned how to make up his own rapid solution, and as a result nickeling at ten to twenty amperes per square foot is very common to-day.

The most recent step in rapid nickeling, if nickel's twin-brother and rival, cobalt, may be included in this category, is the remarkable work of Kalmus and Barrows[1] in plating with cobalt at 150 amperes per square foot, turning out commercial plating of high grade in three minutes.

These achievements with cobalt suggested the desirability of obtaining similar effects with the cheaper nickel solution. In so far as the wonderful results of cobalt solution XIIIB depend upon its extreme concentration (312 grammes of anhydrous cobalt sulphate, equivalent to 585 grammes of the crystallized salt, per liter, or 7½ pounds per gallon) it should be possible to duplicate them with nickel, since its salts are equally soluble. It is in the matter of anode corrosion and in its absorption of hydrogen[2] that nickel is inferior to cobalt as a metal for electroplating.

The nickel anode becomes "passive" on the slightest provocation, and instead of all of the current dissolving nickel as is desired, a portion of it is spent in producing acid at the anode. Besides cutting down the efficiency of deposition, this acid causes hydrogen to be evolved in considerable quantity on the cathode, where some of it is absorbed by the deposit. Absorption of hydrogen by nickel renders it hard and brittle, and is ikely to cause it to curl away from the metal on which it is deposited. The addition of a small amount of some chloride to the sulphate solution usually used for nickel plating is a well-known remedy for this passivity of the anode.

Previous experience with hot nickel solutions indicated their use for overcoming the difficulties just mentioned, since in a hot solution anode corrosion is greatly improved and absorption of hydrogen is lessened.

A 25-gallon (95-liter) hot nickel bath was used at 125 to 150 amperes per square foot (14 to 16 per square decimeter), with great satisfaction, producing in five minutes a heavier deposit than is obtained in an hour from the usual "rapid" bath at ten amperes per square foot. In spite of the extreme current density the deposits were superior in quality and adherence to ordinary nickel plate. Since the electrical instruments and current supply were inadequate for working this bath to its full capacity, a portion was removed to an enameled pail where it could be tested on small cathodes.

This solution contains nickel sulphate (single salt), nickel chloride, and boric acid in the following proportions:

	Grammes/Liter	Ounces/Gallon
$NiSO_4.7H_2O$	240	32
$NiCl_2.6H_2O$	20	3
H_3BO_3	20	3

At the outset the anodes were the same that have been used in the plating laboratory for a number of years, viz., strips of electrolytic nickel. Later cast anodes of the same material were employed. Results of some of these tests are presented in tabular form. (See table 1).

In no case was the deposit "burned." In No. 5 there was a vigorous evolution of gas, indicating a low current efficiency of deposition. Deposits from the hot solution were mat, but polished easily.

It is a matter of general observation that electrolytic deposits become rougher with increasing thickness; when comparing different plating baths it is therefore desirable to know the thickness of the deposits as well as their physical qualities. For the same current efficiency, the thickness of nickel deposited will be proportional to the ampere-hours per unit of surface. By a comparison of the ampere-hours per square foot in the accompanying tables, the relative thickness of different deposits may be estimated. At 100 per cent efficiency one ampere-hour per square decimeter deposits 0.0123 millimeter, and 10 ampere-hours per square foot deposits 0.00052 inch, or 0.001 inch in thickness requires 19.2 ampere-hours. One hour at 10 amperes per square foot, or 10 ampere-hours, is considered good nickeling, and a common cobalt deposit by Barrows was 150 amperes per square foot for three minutes, or 7.5 ampere-hours. Judged by these standards the results shown in the tables are heavy deposits.

In order to secure samples from hot and cold solutions for direct comparison polished aluminium cathodes were used, from which the nickel was easily stripped. (See table 2).

Plating on aluminium brought out the difference between deposits from cold and from hot solutions. An excellent deposit was obtained from the hot solution in every case, which bore polishing without peeling from the aluminium, and when stripped from the latter proved of excellent physical quality. Most of the deposits from the cold solution rolled up and partly separated from the cathode while in the plating bath, and in the few cases where this did not happen the deposit was torn during polishing. No. 53 consisted of five successive deposits for five minutes, each coating being polished and immersed in the electric cleaner for ten seconds before replating. It is 0.0025 inch (0.06 millimeter) thick, and is harder than the usual deposit from a hot solution.

Current efficiency tests were made by reading the current on a Weston model No. 280 ammeter, and determining the weight of metal deposited in five or six minutes. Since a difference of three seconds changes the weight of a five-minute deposit by one per cent, the results are subject to an error of at least this magnitude. Current efficiencies above 90 per cent are obtained in the hot solution at 20 amperes per square decimeter (190 amperes per square foot). It is evident from the tests that heating the solution and lowering the current density raises the current efficiency. (See table 3).

Polarization at the end of No. 52 was only 0.16 volt. Measurements of polarization at 70 deg. Cent. (158 deg. Fahr.) gave 0.15 volt at current densities varying between 13 and 26 amperes per square decimeter (121–242 amperes per square foot). It is therefore probable that hot nickel solutions can be operated at high current densities with less anode surface than is at present used for current densities of 10 amperes per square foot.

In experiments with a solution containing 75 grammes per liter (10 ounces per gallon) of the "double sulphate" two and a half times the current was required to cause burning at 70 deg. Cent. (158 deg. Fahr.) that produced this effect in a cold solution, the weight of metal deposited being the same in the two cases. This indicates that concentration of metal is a greater factor in permitting the extremely high current densities used in these hot solutions than is the temperature. The beneficial effect of heating a nickel solution consists in the improved quality of the deposit, and in better anode corrosion. To avoid convection currents the flame by which the solution was heated was removed at the beginning of each test. At the higher current densities there is noticeable heating of the solution by the current.

A nickel solution that is extensively used consists of the single sulphate, boric acid, and common salt. In order to learn if the substitution of common salt for the nickel chloride of the laboratory plating bath would cause any marked difference in its operation the following solution was tested:

	Grammes / Liter	Ounces / Gallon
Single sulphate	240	32
Sodium chloride	30	4
Boric acid	22	3

Although this solution gave fine results, it is inferior to the bath containing nickel chloride, in not permitting the use of so high a current density. (See table 4).

To make up the bath with nickel chloride proceed as follows: Dissolve the nickel salts in the proper amount of hot water, add nickel carbonate in small amounts at a time and heat until all acid is neutralized; either filter

TABLE 1.

Exposure.	Temperature Deg. Cent.	Temperature Deg. Fahr.	Time Minutes.	Amperes per Square Decimeter.	Amperes per Square Foot.	Ampere-Hours per Square Foot.	Deposit.
No. 10	67	153	5	31.7	295	24.5	Fine.
No. 48	71	160	5	47.6	422	28.0	Good.
No. 54	92	198	1	95.3	890	14.8	Fine.
No. 4	25	77	3	5.3	49	3.0	Fine.
No. 5	25	77	6	14.0	130	6.5	Mat, polishes well.

TABLE 2—DEPOSITS ON ALUMINIUM.

Exposure.	Temperature Deg. Cent.	Temperature Deg. Fahr.	Time Minutes.	Amperes per Square Decimeter.	Amperes per Square Foot.	Ampere-Hours per Square Foot.	Deposit.
No. 12	74	165	20	18.9	176	60.3	Fine, mat.
No. 14	35	95	12	11.7	109	22.6	Rolled up, brittle.
No. 15	38	100	22	8.2	76	27.9	Mat, tore in buffing.
No. 49	71	160	5	24.2	225	18.7	Fine.
No. 50	78	172	10	30.7	285	47.6	Fine. 0.002 inch (0.05 millimeter) thick.
No. 53	98	208	25	15.2	141	60.0	Five successive deposits.

TABLE 3—CURRENT EFFICIENCY TESTS.

Exposure.	Temperature Deg. Cent.	Temperature Deg. Fahr.	Time Minutes.	Amperes per Square Decimeter.	Amperes per Square Foot	Ampere-Hours per Square Foot	Cathode Efficiency Per Cent.
No. 11	45	113	6	31.1	289	28.9	89.6
No. 13	29–40	84–104	6	31.1	289	28.9	19.4
No. 16	60–70	140–158	13	8.6	80	17.3	100.9
No. 46	25–28	77–82	5	19.4	180	15.0	31.7
No. 48	91–84	196–183	5	9.5	88	7.4	98.0
No. 51	77–73	171–163	6	26.4	245	24.5	100.5
No. 52	76–84	167–183	6	51.3	477	47.7	99.2

TABLE 4—TESTS OF BATH WITH SODIUM CHLORIDE.

Exposure.	Temperature Deg. Cent.	Temperature Deg. Fahr.	Time Minutes.	Amperes per Square Decimeter.	Amperes per Square Foot	Ampere-Hours per Square Foot	Cathode Efficiency Per Cent.	Deposit.
No. 42	32	90	5	19.0	177	14.7	25.6	Good.
No. 43	71	160	5	19.6	184	15.3	82.3	Burned one edge.
No. 44	76	169	5	20.8	193	16.1	82.8	Burned one edge.
No. 86c	84	183	3	20.2	187	9.3	....	Fine.
No. 68d	78	172	4	25.3	234	15.6	....	Burned.

* A paper presented at the twenty-ninth General Meeting of the American Electrochemical Society.

[1] Transactions American Electrochemical Society (1915) 27 75.

[2] *Idem.* (1915) 27, 121.

or allow to settle and decant the clear solution, and finally add the boric acid.

In so far as anode corrosion is concerned, any soluble chloride might be substituted for the nickel chloride, but not without some effect on the character of the deposit. Magnesium chloride or sodium chloride seems to be preferred for this purpose. In case either of these is used, neutralizing might well be done by the carbonate of the same metal. Ammonium salts and the "double sulphate" of nickel are to be avoided, since they are likely to cause crystallization from solution when cold.

To obtain the best results from a hot solution the current density must be high; cables and tank rods must therefore be of ample capacity. Control of a hot solution by regulation of the amount of anode surface will probably be easier than in a cold bath. The heating coil should be of heavy lead (or hard lead) pipe, with a settling space of five or six inches below the lowest coil; lead will also serve as a lining for the tank. If an electric cleaner is operated from the plating dynamo, either the heating coil should be electrically insulated, or all rheostats should be connected on the cathode side of the line. Should gas pitting occur on first using the solution in the morning, it may be avoided by heating the bath to boiling for a few minutes before beginning plating. Seventy deg. Cent. (158 deg. Fahr.) is a good temperature at which to operate a hot nickel bath.

Owing to the peculiar properties of electrolytic nickel, the advantages of a hot over a cold solution are greater in nickel plating than in the deposition of any other metal.

ADVANTAGES OF A HOT OVER A COLD NICKEL SOLUTION.

1. Heating from 25 to 70 deg. Cent. (79 to 158 deg. Fahr.) lessens the resistance of the solution by one half.

2. The current density may be increased two and a half to three fold.

3. The current efficiency, if less than 100 per cent in the cold solution, is raised.

4. Anode corrosion is greatly improved, and higher current densities may be used at the anode as well as at the cathode.

5. The deposit is superior to ordinary nickel plate in toughness and freedom from peeling.

6. In the solution tested, plating may be done at 200 to 300 amperes per square foot (22 to 33 per square decimeter), at which rate the same amount of metal is deposited in five minutes as requires one and a half hours in the "rapid solutions" now in use at ten amperes per square foot.

Nightblindness*

By Dr. M. Meyerhof

A NUMBER of observations of nightblindness have been published during the present war which were made on soldiers in the field. The impossibility to find their way at night brought the men thus afflicted soon under medical treatment. Braunschweig[1] has in a short time had occasion to examine 27 such cases among widely different parts of the army; Zade[2] 12, Best[3] 36, and Paul[4] 16. All of these cases were seen at the scene of the war during the trench fights and especially in winter. Aside from errors of refraction, the eyes never showed any symptoms of disease; malnutrition was in most cases not to be thought of. Bitot's spots on the bulbar conjunctiva were always absent. A number of wounded officers with whom I had occasion to speak, affirmed that they had seen here and there cases of nightblindness among their men. All of these cases had occurred in the trenches and especially during the winter of 1914 to 1915. The moving war in the East, though fraught with much greater bodily strains and an often poor food supply on account of the bad roads and the rapid advance, seems to have brought about such cases of nightblindness but rarely. (Compare Uhthoff.)

It may be of interest to relate similar observations from the literature of the Napoleonic wars, although it is not possible to make at this late date a correct diagnosis.

When Bonaparte moved in 1798 with his just landed army from Alexandria to Cairo, his soldiers quite naturally suffered terribly from heat, thirst, sun blinding, and —in consequence of lack of foresight as regarded the poor supplies of the Nile land—from hunger. To this was added the tiring, severe service on night watches against the opposing bedouins and fellahin who sneaked forward without making a noise, so that, for instance, early on July 5th a severe night battle took place in the divisions of General Bon. On July 16th, four days previous to the battle at the pyramids, Detroye,[5] chief of a battalion of engineers, wrote in his unpublished diary: "A number of soldiers have been attacked by an eye affection and cannot see by night." Since the serious inflammation of the eye, which later on ravaged the French army in such a terrible manner, began only in August, these were probably isolated cases of nightblindness. However, neither the chief surgeon Larrey,[6] nor the physician in chief Desgenettes[7] mentioned any such cases. It must be remembered that nightblindness is found even to-day epidemically among the badly nourished fellahin, especially the chilren, and particularly in certain regions of the Nile delta in which pellagra, too, is not rare on account of living on bad maize. I have not been able to find any other mention of nightblindness in any of the numerous writings on the campaigns, so full of deprivations, made by the French or English in Egypt and Syria.

On the other hand, Robert,[8] physician in chief of the military hospitals during the siege of Malta (1798 to 1800) gives a more accurate description of nightblindness which raged epidemically among the shut-in French troops.[9] In October, 1798, the blockade was completed by the English fleet. At the end of December scurvy was already rampant, so that in February, 1799, over 400, and in April 636, men suffered from it. Most of these patients complained at the same time of nightblindness. "The nyctalopia (sic)," says Robert, "is that form of eye disease in which patients cannot see at night. It is easy to recognize such patients; their pupils are large and considerably dilated. At night they cannot at all differentiate between objects. This disease attacks most frequently cachectic individuals with flabby tissues. . . . During the winter of 1798-99 (year VII.) this disease was epidemic at Malta. The soldiers of Forts St. Angelo and St. Elmo suffered especially from it, while those of Fort La Florina remained perfectly free from it. The first named forts lie in the lowest part of the city, at the seashore, while the Florina lies highest and near the country. Cold, moisture and night chills, together with insufficient food, are, therefore, the distant causes of nyctalopia; I especially mention the poor food, because the first cause alone could not have produced the nightblindness. There are frequent cold and moist winters at Malta and, yet, nightblindness had not occurred before. . . . At the same time when this nyctalopia appeared many individuals were attacked by diarrhœas or colds, others by discharges from and tearing of the eyes; those suffering in this way did not show nightblindness to the same extent. .... The immediate cause of this disease is, therefore, an atonic condition, tiring and diminution of sensitiveness of the visual organ. Although the prognosis of this disease was free from any danger, still it caused considerable anxiety. Those afflicted by it could not stand guard on the walls of the forts by night. Fumigations of animals' livers and aromatic plants cured the disease. It reappeared, however, after a short time. During the whole time of the winter, as long as the conditions underlying it continued, it could not be cured; as soon, however, as the conditions of the soldier could be improved, and as soon as the cold and moisture had given way to the agreeable warmth of spring, the sensitiveness of the visual function returned and the disease disappeared." Soon thereafter the scurvy, also, disappeared by which 300 men had been affected. Although the siege lasted till September, 1800, that means through a second winter, Robert does not mention this disease any more.

This was probably a real epidemic nightblindness, as it used formerly to be quite frequent (mostly combined with xerosis conjunctivæ) in prisons, schools and among ships' crews[10] in consequence of the lack of green vegetables. Yet, it was not observed during other prolonged sieges in the 19th century (for instance at Hamburg, Sebastopol, Paris); as also at Port Arthur in 1904 and Przemysl, 1914-1915.[11] It is notable that the nightblindness at Malta diminished when spring came and even disappeared. Braunschweig and Paul, too, saw their cases during winter. If exhaustion and undernutrition are to be accused, such reports of nightblindness should surely have been expected in the communications concerning the French campaign in Russia in 1812. There are, however, none from the relations of individuals who took part in that campaign and none in the medical description of the Belgian military surgeon Von Kerckhove.[12] He mentions only a slight epidemic infection of the eyes at the beginning of the campaign and severe ophthalmia during the retreat, a purulent discharge, which often led to blindness and was later on transmitted to the Prussian troops. Once (p. 168) he says, that many soldiers suffered from weakness of vision, even blindness, which was looked upon as "exhaustion of the irritability of the retina on account of the blinding snow." This was with probability in reality rather snowblindness than nightblindness. Larrey says occasionally (*Clinique Chirurgicale, exercée particulièremant dans les camps et les hôpitaux militairs*, etc. T. V. Paris, 1836) that during the Russian campaign of 1812 blindness from amaurosis (gutta serena) occurred quite frequently.

Uhthoff[13] has recently stated that during the campaign in Russia in 1914-1915 he has seen few cases of nightblindness, in spite of exhaustion and deprivations.

From all these communications it is impossible to get a definite knowledge of these cases of nightblindness, developed in the field. In the two cases which thus far I have observed it was caused by corneal opacities and astigmatism. On the other hand, I know from a reserve batallion that it has among its men several with congenital, probably hereditary, nightblindness who on account of this defect are unfit for guard and field duty. The heredity nightblindness in the French family Nougaret was indeed detected by Cunier in 1838, because a soldier of this family had been found inattentive on guard duty, and had been wrongly punished. We must, therefore, assume with Best that there is no uniform cause for the cases of nightblindness, which have been observed in this war. A careful distinction of the cases according to his method and the observation of their curability will greatly improve our knowledge of this as yet enigmatical disease.

While these remarks were written, a paper by H. Feilchenfeld appeared, who has seen nightblindness, usually among miners, only associated with nystagmus and in diseases of the fundus. Sometimes it was simulated to escape work.

Professor Hirschberg drew my attention to the fact that in his book on "Aegypten" (Leipzig, 1890, p. 100), he has mentioned a report of the crusades which bears on our subject. It refers to the unhappy campaign of Johann von Brienne into Egypt and the capitulation of the crusaders at Damiette in 1221 A. D., related by Oliverius Scholasticus in Historia Damiatina (Eccard, Corpus historæ medii aevi II, 1414): "Ex angustia famis diversa morborum genera vexabant cos et inter cetera incommoda quae sustinuerunt noctibus velut ærisia (aorasia) percussi apertis oculis nihil viedre dicebuntur." Hirschberg adds that this was evidently nightblindness from lack of nutrition, and explains in a footnote the word aorasia as blindness as it is used in the septuaginta translation of the Bible.

Centribl. f. Prakt. Augenblk., Jan., Feb., 1916.

[1]Braunschweig. Kurze Mittheilung ueber die epidemische Hemeralopie im Felde. *Muench. med. Wochenschr.*, 1915, No. 9, p. 303.

[2]Zade. Ueber Augenerkrankungen im Felde. Ibidem, No. 23, S. 800.

[3] Best. Ueber Nachtblindheit im Felde. Ibidem, No. 33, p. 1121.

[4]Paul. Beobachtungen ueber Nachtblindheit im Felde. Ibidem, No. 45, p. 1548.

[5]Cited by De la Jonquiére, L'Expedition d'Egypt, 1798 to 1801.

[6]D. J. Larrey. Relations historique et chirurgicale de l'expedition de l'Armée d'Orient. Paris, A. XI, 1803.

[7]R. D. Desgenettes. Histore médicale de l'Armée d'Orient. An. X, 1802.

[8]Robert. Mémoire sur la topographie physique et médicale de Malte. An XI, 1803.

[9]Robert gives a special chapter to nightblindness, entitled "nyctalopia," while he had previously called the same affection "héméralopie," which is the usual term nowadays. For the Hippokratics a nyctalops is a day blind; for Galen and the later authors the night blind.

[10]Fr. Tyrrell (A Practical Work on the Diseases of the Eye, vol. II, London, 1840), relates that it was particularly frequent on English ships in the ports of the East and West Indies and was called moonblindness by the sailors.

[11]The Regimental Physician, Dr. R. Pamperl (*Mediz. Klinik*, 1915), says that scurvy, too, appeared only after the end of the siege among Austrian prisoners in the hospitals.

[12]Histoire des maladies observées à la Grande Armée française, pendant les campagnes de Russie en 1812 et d'Allemagne en 1813. Par le chevalier J. R. L. de Kerckhove dit de Kirchoff. Troisiéme Edition, Anvers, 1836.

[13]Sitzung der Med. Section der Schles Ges. f. vaterlaend. *Kultur*, Nov. 19th, 1915; *Med. Klinik*, 1915, p. 1361.

Water Power in the United States

REVISED figures of the potential water power resources of the country place them, says the report, at the minimum of 27,943,000 horse-power and the maximum of 53,905,000, the minimum representing the amount of power that could be developed from the use of the average annual minimum stream flow for the lowest two consecutive seven-day periods of each year, while the maximum represents the amount that could be developed from the use of the average maximum continuous stream flow available for six months during the year. The national forests are stated to contain 30.4 per cent of this minimum and 31.3 per cent of the maximum, while over 72 per cent of the country's total is found in the Mountain and Pacific States and 42 per cent in the three Pacific Coast States. National forest water power amounts to 42 per cent of the minimum and 43 per cent of the maximum estimated power resources of the Western States.—*Report of the United States Department of Agriculture.*

The Restoration of the Dinosaur Podokesaurus Holyokensis

With Reproductions of the Authors Original Drawings

By Dr. R. W. Shufeldt

Four or five years ago, Dr. Mignon Talbot, Professor of Geology in Mount Holyoke College, discovered the fossil remains of a very interesting little dinosaur, upon which she bestowed the name of *Podokesaurus Holyokensis* owing to the fact that it was found in a bowlder of Triassic sandstone, not a great way from Mount Holyoke College, having been carried there by a glacier.[1] The type specimen is now in the aforesaid institution, and has been studied by a number of our most eminent palæontologists, as Doctors Charles Schuchert, Richard S. Lull, and others. Very recently Dr. Lull has elaborately reviewed and augmented our knowledge of this diminutive member of the dinosaurian group, and has placed it in a family apart—the *Podokesauridæ* of the superfamily *Compsognatha*—in which group we find those "slender limbed, agile dinosaurs" such as "*Compsognathus* of the Solenhofen lithographic limestone (Middle Jurassic)," and others.[2]

Dr. Talbot, in her original description, gives a very elaborate account of *Podokesaurus*, comparing it with a number of orthopod and theropod dinosaurs, and considers the fossil she discovered to be one of the carnivorous types "because of the length, shape, and position of the pubis and the absence of a postpubis." Dr. Lull carries this description much further, and in his "Triassic Life of the Connecticut Valley" he gives a very elaborate account of the skeletal remains of the animal in the slab, as developed by Mr. Hugh Gibb at Yale University, to which institution it had been loaned by the authorities in Mount Holyoke College for a second examination. Dr. Lull illustrates his description with a number of cuts; Figs. 1 to 3, Pl. XI, are apparently reproductions of photographs of the exposed skeleton of *Podokesaurus holyokensis* in the slab; Fig. 26 (text cut) reproduces Dr. Talbot's determination of the various bones of the fossil and gives them in outline as they rest in the matrix, while Fig. 27 (text cut) presents Dr. Lull's conception of the pelvic region and the bones found near it. This last cut I have copied, reproducing it here in Fig. 1 of the present article.

Figs. 30 and 31 of Dr. Lull's detailed account present, respectively, restorations of *Compsognathus longipes* and *Podokesaurus holyokensis*—the entire skeleton in each instance.

When I first examined the positions claimed for the bones, here shown in Fig. 1, it struck me that the pubis (*Pu*) could not have occupied the position given it in the restored skeleton, notwithstanding the fact that it has the place that it occupies in the matrix—which may or may not be a good reason for retaining it there in a restoration.

In discussing this question with Mr. Charles W. Gilmore, Curator of Fossil Birds and Reptiles in the United States National Museum, on whose opinion in such matters I place great store, he came to the same conclusion that I had formed. He remarked that he did not believe that any animal's pubis would hold any such position as shown in Dr. Lull's restoration (Fig. 31, Lull's restoration as cited above), for the reason that it would come in contact with the costal ribs during various movements on the part of the animal, not to say what it might do in the case of the abdominal viscera and other organs.

In a letter dated at Copenhagen August 11th, 1915, my friend Hr. Gerhard Heilmann, the distinguished Danish naturalist, wrote me to the effect that "Prof. Lull has sent me his 'Triassic Life of the Connecticut Valley.' I suppose that his book also is in your possession. The description does not seem to me to justify the position of *Podokesaurus* among dinosaurs, and no other suggestions are discussed. After Talbot is *Podokesaurus* a carnivorous dinosaur, 'because the length, shape, and position of the pubis and the absence of a postpubis' (Lull, p. 162). But just the pubis I think to be extremely bird-like, as I have written before (in my part II), the 'obturator notch' (p. 168) is probably the part of the bone which has touched the ischium (see the inclosed reconstruction).[3] And that part which in Lull's Fig. 27 touches the ischium should be posed as to form the lower part of the acetabulum. You will see nearly the same pelvis of a chicken.

"I should very much like to know if anything in the skeleton of *Podokesaurus* contradicts that the animal was a pro-avis; and I would greatly appreciate to be able to refer to the opinion of the excellent osteologist Dr. R. W. Shufeldt about this. It seems to me that all the bones, which undoubtedly indicate to us that it is not the remains of a bird but of a dinosaur, are wanting.

"The bones on Plate XI., Fig. 3, are not easy to locate, but they could as well be remains of a bird's skull. One of them (*B* in Fig. 29) has some resemblance with palatinum.

"Excuse the errors in this letter; I have no vocabulary here (the Isle of Fyn, Denmark), and therefore it is difficult for me to say just what I will."

Before giving in substance what I had to say in my several letters on this subject to Dr. Lull and Hr. Heilmann, it will be as well to note that a correspondence had been opened between them, and some important statements made in a letter from Hr. Heilmann to Dr. Lull are published by the latter in a footnote in his "Triassic Life of the Connecticut Valley" (p. 165), which reads as follows: "Herr Gerhard Heilmann of Copenhagen, to whom that portion of the present work describing *Podokesaurus* was submitted for criticism, says of my restoration of the animal (Fig. 31): 'Prof. Lull's placing of the pubis is not convincing, on the contrary, his description seems to make it still more probable that this bone is entirely brought out of position, the ilium and the proximal end of the tail being totally wanting, and thus these must have been removed before the bones were covered by sand. Dr. R. W. Shufeldt supposes (in a letter) that the reptile may have been a subadult individual, and the prepubis not thoroughly co-ossified with the ilium and ischium in the cotyloid cavity. This seems very probable.

"'A pubis protruding into the chest of the animal looks indeed too heterogeneous to be trustworthy.' [Original author's translation, from Heilmann, 1913, B. p. 64."] This is probably a translation of a statement made in one of the parts of Hr. Heilmann's very useful work "Our Present Knowledge of the Origin of Birds."

Quite an extensive correspondence, in which I took part, followed upon this; and while I have my share of it retained as filed carbons of my original letters on the subject, it will by no means be necessary to reproduce it in the present connection. For the most part my letters were addressed to Dr. Mignon Talbot, Dr. R. S. Lull, and Hr. Gerhard Heilmann, and touched upon the apparently unnatural position given the pubis in Dr. Lull's restoration; upon the probability of the specimen having been a subadult individual at the time of its death; upon the question as to how far we should be guided by the positions assumed by the bones in the resulting matrix in employing those various positions and their relation to each other in restoring fossil vertebrates at large; upon the question as to whether *Podokesaurus holyokensis* was an herbivorous or a carnivorous dinosaur; upon the question as to how much bird there was in its skeletal morphology, and, finally, upon the desirability of still further developing the remains in the original slab.

Hr. Heilmann, in his drawing here shown in Fig. 2, did not get the pubis (*Pu*) nor the ischium (*Is*) of the same form and outline as given by Dr. Lull in Fig. 1. The *notch* at the proximal end of the pubis (*Pu*) in Heilmann's figure is too long and shallow, and the ischium is swelled to fit this notch. To still further develop his idea as to the relations of these bones, but without accepting his conclusions in full, I made the drawing here shown in Fig. 4, in which both the ischium (*Is*) and the pubis (*Pu*) are careful tracings of those bones as given us in Dr. Lull's figures, and of the same bones as they appeared in photographs of the specimen in the slab kindly furnished by Dr. Talbot, which passed through my hands on their way to Hr. Heilmann. If the *Pubis* in life had the position I have given it in Fig. 4, it would be more like the place it assumes in the herbivorous dinosaurs than in the carnivorous ones. Moreover, it would better support Hr. Heilmann's view that *Podokesaurus* was a "Proavis" and not a true dinosaur at all. If my recollection serves me aright, it was Marsh who said that many of the *very* small dinosaurs which had been discovered in this country were extremely bird-like in their skeletal structure, and that in some instances it was quite difficult to draw the line between the two.

In *Claosaurus annectens* for example, apart from its large pre-pubis (Fig. 3, *p'*), the bones in question have a very bird-like arrangement; and were the pre-pubis

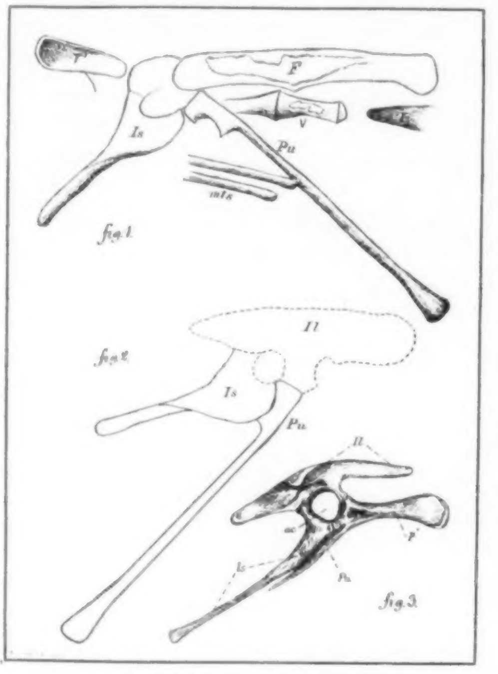


Fig. 1.—Pelvic region of *Podokesaurus holyokensis*; natural size; original. After Lull (Fig. 27, Trias. Life Conn. Valley), *F*, right femus; *Is*, ischium; *mts*, metarsals; *pu*, pubis; *T*, *T'*, tibia; *V*, presacral vertebra.

Fig. 2.—Pelvis of *Podokesaurus holyokensis*. After Gerhard Heilmann. *Vide* his letter to the author of August 11th, 1915. *Il*, ilium; other lettering same as in Fig. 1.

Fig. 3.—Right lateral view of the pelvis of *Claosaurus annectens*. About one eighteenth natural size. After Marsh. *ac*, acetabulum; *p'*, prepubis (or *pubis* of many authors).

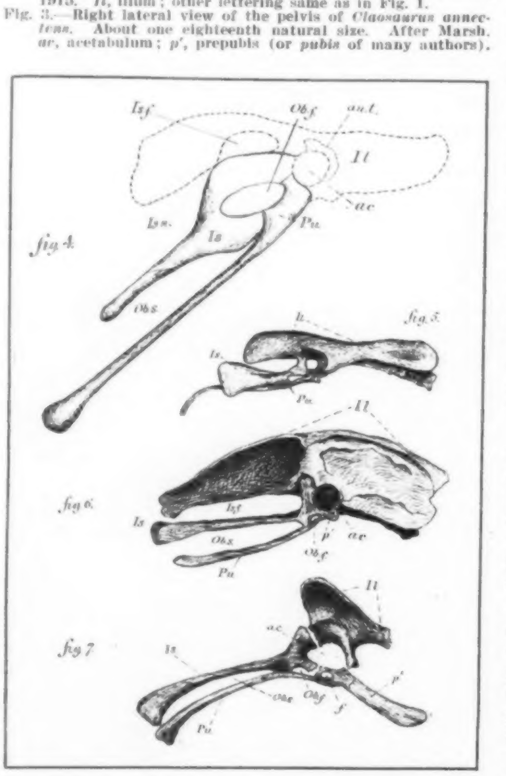


Fig. 4.—Right lateral view of a possible arrangement of the pelvic bones in *Podokesaurus holyokensis*; by the author. *Is. f*, ischiadic foramen; *Ob. f*, obturator foramen; *an. t*, antitrochanter; *Ob. s*, obturator space; *Is. n*, ischiadic notch.

Fig. 5.—Right lateral view of the pelvis of a subadult specimen of the sage cock (*Centrocercus urophasianus*). Arrangement of the bones prior to their final co-ossification. Specimen collected by the author, who made the drawing. Lettering as in previous Figures.

Fig. 6.—Pelvis of emu (*Dromaeus novae hollandiae*, Lath.); right lateral view. After Marsh. (*Odontornithes*, text, Fig. 16). Lettering as before.

Fig. 7.—Right lateral view of the pelvis of *Comptosaurus medius*. Forepart of ilium off. After Gilmore. Lettering as in Figs. 1 and 6.

NOTE.—Dr. Shufeldt read this paper before the Biological Society, Washington, D. C., on March 25th, 1916, and illustrated it by slides of the accompanying original drawings.

[1] M. Talbot, 1911, *Amer. Jour. Sci.*, (4) xxxi., pp. 469–479 pl. IV., text figs. 1–6.

[2] Richard Swan Lull. "Triassic Life of the Connecticut Valley," *State Geol. and Nat. Hist. Surv. Bull 24*. published by the State of Connecticut, 1915. Pub. Doc. No. 47.

[3] The "inclosed reconstruction" to which Hr. Heilmann refers, is a tracing he kindly made for me of his drawing, in which he throws the pubis (*Pu*) *backward* instead of forward, as Docter Lull has it. This drawing I have reproduced in Fig. 2 of the present paper.

greatly reduced, this pelvis would be very much like the diagrammatic one shown in Fig. 2. How this would affect Hr. Heilmann's theory it is not necessary for me to state here.

Fig. 4, as I have drawn it, comes nearer to the bird pelvis (see Figs. 5 and 6), and I believe to be more nearly a conception of a proavine arrangement of the elements than shown in Fig. 2. This will at once be appreciated by comparing the pelves in question with that of *Camptosaurus medius* (Fig. 7).

In his letter to me of October 8th, 1915, Hr. Heilmann says: "You have quite correctly supposed what I mean by the term 'Proavis,' it is one of the connecting links between Aves and Reptilia—but somewhat more bird than reptile; a forerunner of Archæapteryx.

"The skeleton of this Proavis I am about to reconstruct—using the same method as you perhaps have seen me employ in my reconstruction of the intermediate links between the pelvis of Archæapteryx and that of Aptornis in Prof. D'Arcy W. Thompson's 'Morphology and Mathematics,' p. 885 fll.[4] The method is quite trustworthy, as I have proved in constructing for his new book the links between the skulls of Eohippus and Equus. Among these reconstructions we find the skulls of both Nesohippus and Protohippus but not that of Parahippus, which the palæontologists (Zittel: *Grundzuge der Palæontologie*, 1911, p. 463) consider to be in the straight line between Eohippus and Equus. From the reconstructions it is evident that Parahippus belongs to another stem.

"For finding the Proavis the right starting point is of most importance. I quite consent with Broom in his guess that it is among the Pseudosuchia (so he names the Parasuchia) that we shall seek the reptile from which the bird-stock has originated. It is also between such a reptile (drawn with traits of character from both Ornithosuchus and Euparkeria) and Archæaptheryx that I am constructing some intermediate links.

"With respect to *Podokesaurus holyokensis* it would, of course, be quite ridiculous if I, having only seen photos of the slab, would assert that *Podokesaurus* is not a dinosaur, when the American palæontologists insist upon its being just this. But when such important parts as the skull, nearly the whole forelimb and the ilium are wanting, the decision must be very doubtful, because the longer we go back in time we see the different orders more and more converging, and at a sufficient early moment we shall not be able to say if some fossil remains are from Aves, Dinosauria, Pseudosuchia, or Pterosauria.

"*Podokesaurus* is the earliest known dinosaur, and it would surely not be difficult for me to make a reconstruction of the skeleton with much more avian characters than that of Prof. Lull. It therefore seems to me to be a great want in Dr. Talbot's and Lull's description of the fossil that they not with a single word have explained, why the remains can not belong to the Pseudosuchia or to the birds.

"What you write about *Podokesaurus* we have discussed before; it is stated in my paper, Part II, page 64. And in his 'Triassic Life of the Connecticut Valley' Dr. Lull brings my translation of that point, page 165 in the footnote. It then is your true conviction that the pubis has been wrongly placed in Dr. Lull's restoration; you write: 'The notch at its proximal extremity undoubtedly formed a part of the acetabulum, and the long shaft of the bone was directed backward and downward.' And furthermore you 'would say that the hinder portion of the ischium is not in view, and that it was probably much more extended posteriorly, so as to be nearly as long as the pubis.'

"But if this be so, what a revolution in our views of dinosaurs! A dinosaur with a pubis turned backward as in birds, with an ischium also very birdlike, and consequently with a pelvis nearly more birdlike than that of Archæapteryx! Have you thought of what the descendants of such a reptile would be? Surely not dinosaurs! At one time turned backward, the pubis must remain so; it cannot move forward again. This we also can see from the embryonic evolution. You have never seen, and will never see (I am sure) a dinosaur with a long, slender pubis turned backward. But if we go to the Pseudosuchia you can see the pubis on the move. In the pelvis of Euparkeria Capensis, which I have drawn here after Broom, you will observe that the pubis passes nearly straight downward with a plain flexion backward (R. Broom in Proceedings of the Zool. Soc., 1913, vol. 2).[5]

"Besides you write about the skeleton of *Podokesaurus*, 'and to me the piece *S* has more the form of the *hypocleidium* of the united clavicles, than it has of either the sternal extremity of a coracoid, or still less either extremity of a scapula.' Are you aware that, by saying this, you also go outside the limits of dinosaurs? No dinosaur has hitherto been found in possession of neither *claviculæ* nor *episternum* (your *hypocleidium* I suppose to be = episternum = interclaviculare, my Fig. 146). But these we see in the Pseudosuchia.[6]

"If I may quote your opinion about these different bones in *Podokesaurus*, I am obliged to draw the here mentioned conclusions from them. Dr. Lull writes about *Podokesarus* (p. 168) that the metatarsals 'are so closely

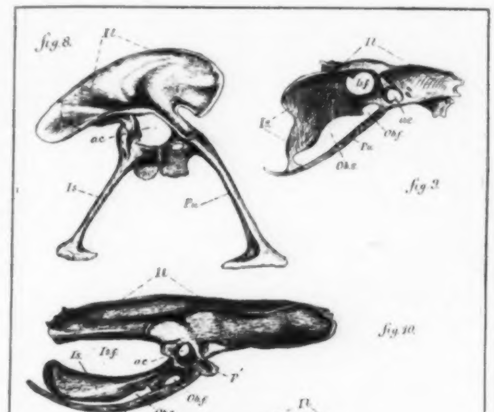


Fig. 8.—Right lateral view of the pelvis of *Ceratosaurus nasicornis*. After Marsh. Lettering as in previous Figures.
Fig. 9.—Pelvis of the ivory-billed woodpecker (*Campephilus principalis*). Lettering as before. Specimen in Coll. of the U. S. Nat. Mus. By the author.
Fig. 10.—Right lateral view of the pelvis of a tinamou (*Tinamus robustus*, Sclater and Salvin). After Marsh (*Odontornithes*, text Fig. 20, page 73). Lettering as in previous Figures above.
Fig. 11.—Pelvis of *Stegosaurus stenops*; right lateral view. Lettering the same as in previous Figures. After Marsh.

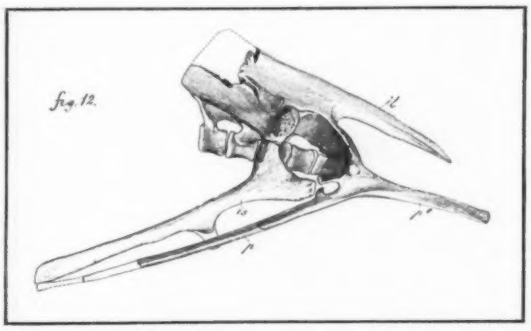


Fig. 12.—Right lateral view of the pelvis of *Thescelosaurus neglectus* Gilmore. Lettering as before. From an advance proof of Fig. 17 for Mr. Gilmore's paper on the "Osteology of *Thescelosaurus*, an Orthopodous dinosaur from the Lance formation of Wyoming," Proc. U. S. Nat. Mus., Vol. 49.

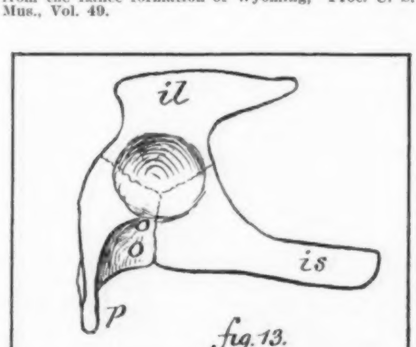


Fig. 13.—Left lateral view of the pelvis of *Euparkeria capensis*. Reduced. Shufeldt after Heilmann after Broom.

appressed together as to form a wonderfully compact structure, perhaps even more so than Marsh has described for Ornithomimus.' It is then impossible that *Podokesaurus* can be the ancestor to Ornithomimus and Ornitholestes, which Dr. Lull has written in his manuscript delivered to me (see my translation in my Part II, page 63). This passus he has omitted in his recent work (see there page 169). His earlier comparison (in his doctor thesis of 1904) between the footprints of dinosaurs and of birds, which I have proved to be a plain mistake, he does not mention with a single word in his last work, though it should be considered only reasonable to correct this mistake just there; besides he had written to me that he would do so.

"Just as I am writing this I get a letter from Prof. Lull in which he, among other things, writes about *Podokesaurus*: 'So far as its being a proavian is concerned, I know nothing to the contrary.' "

I must leave it to the readers of this article as to what Hr. Heilmann intends to convey, when he expresses his surprise at my saying that the *pubis* in certain dinosaurs is directed backward and downward. In reply to this I would say that not all of the pelves of dinosaurs are fashioned like the one here shown in Fig. 8, for we also find them like those reproduced in Figs. 7, 11 and 12. It is most interesting to compare the pelvis of the small dinosaur *Thescelosaurus neglectus* (Fig. 12) with that of an Emu (Fig. 6). Note the close resemblance in the ischii, in the bent "backward and downward" pubis bone, and the presence in each of a prepubis (p'). It would not be very difficult to build up a *bird* skeleton with the bones shown in Fig. 12 to start with; and yet palæontologists in this country have not, up to the present time, considered *Thescelosaurus* a *proavis*.

In a valued letter from Dr. Lull, dated September 11th, 1915, he says: "So far as *Podokesaurus* is concerned, the positions of the various pelvis elements in my restoration are those which the bones have in the rock, and we have always argued that a fossil bone in position in the rock is worth more as evidence of its true position than any amount of argument. In other words, I think both you and Mr. Heilmann will have to prove your statement, and that until you can, the pubis ought to remain as it is."

This argument, in my opinion, will not apply or still less hold in the case of *Podokesaurus Holyokensis* at all; for, if we but glance at Fig. 1 for a moment, bearing in mind that it represents the positions of all the bones there shown as they are actually related to each other in the "rock"—and were we to accept these positions as the correct ones—we should see one tibia sticking out beyond the ischium, the other in line and in front of the sacral vertebræ, a femur on top of the latter, and the metatarsals belonging somewhere between the pubis and the ischium! All of which is, of course, ridiculous.

As a matter of fact, all of these bones are far removed from their normal positions, as compared with the several positions they would have normally occupied in the living animal. I still contend that the specimen was a subadult individual, which died before the pelvic bones had fused together, and that the *pubis* formed no exception to the mix-up that took place before all the bones drifted to those positions which they eventually occupied in the solid matrix or rock in which they were found. The fact that, in a lot of mixed-up bones, the long, rodlike pubis was found directed to the front—as compared with the hinder extension of the ischium—will, in this instance, be no sound argument that it belonged there in life, where it would, beyond all cavil, be a constant menace to the very vitals of the animal when it came to perform many of the ordinary acts of its life.

On the 11th of October, 1915, I received another very valuable letter from Dr. Lull, in which he said: "I still have your letter of September 13 before me unanswered, and I am very much impressed by what you say as to the value of the evidence used in making restorations. I really feel, with Prof. Schuchert, that in the case of *Podokesaurus* one ought to go up to Mount Holyoke and study the skeleton again and find out whether there is evidence of shifting of that pubis out of its natural position or not. The skeleton is to a certain extent definitely articulated, and under the circumstances I supposed that the bones which were in what could be a natural position for a dinosaur should be taken as correct, until Mr. Heilmann's criticism first came to me. Do you realize that instead of being slender, rod-like bones, these bones are broad, plate-like structures, not bird-like at all but very similar to the pubic bones of Triassic dinosaurs which Von Huene and Eberhard Fraas have found and described? Of course, Huene's actual opinion, other than his published statements, is now unavailable, because he is somewhere in the trenches fighting against the Allies, and Fraas is dead and much of his evidence is as yet unpublished, but he had creatures which he supposed to be dinosaurs which apparently showed affinities with *Podokesaurus*. What you and Heilmann are trying to do is to see avian characters in the animal, while Huene, Fraas and I see dinosaurian characters, and your argument is just as good for the placing of the pubis as I have it as for the placing of the pubis as you see it. I wish you, yourself, might see the original skeleton. We have a cast of it here but that is not sufficient.

[4] I am indebted to Prof. Thompson for a copy of this most invaluable monograph, which was published in 1915 in the *Transactions of the Royal Society of Edinburgh*. What Hr. Heilmann sets forth in this work on pp. 885–888 (Figs. 48–54) goes a long way toward sustaining what he means by a "Proavis." R. W. S.

[5] See Fig. 13 of the present article.

[6] Hr. Heilmann seems to have overlooked the fact here that I did not say *it was* the "hypocleidium," but that it *looked more like* that bone than it did the sternal extremity of a coracoid or any part of a scapula. R. W. S

I am sure Miss Talbot will give you every facility for studying it, should you so desire."

After receiving this most courteous letter, I at once put myself in communication with Miss Talbot, in due course receiving from her the following communication, dated at Mount Holyoke College, the 10th of November, 1915: "Dear Dr. Shufeldt:

"I am very sorry to have kept you waiting so long for an answer to your letter in regard to *Podokesaurus*, but I am far from well this fall and the trip to New Haven seems to have upset me completely, so that I have been able to do my regular work, only, and have had to let everything else go.

"I am not at all sure that I shall not publish a little note in regard to *Podokesaurus* myself before long, taking issue with both you and Prof. Lull, in regard to different bones, however,. This being the case, I hardly want to send you the photographs that I am to have taken soon, nor do I want to give you the results of my study.

"I should be very glad, however, to have a digest of the remarks that Prof. Heilmann has made on the fossil. . . .

"Very sincerely yours,
(Signed) Mignon Talbot."

Before receiving this letter I had had another most instructive one from Dr. Lull, dated at Yale University the 22nd of October, 1915, which ran thus:

Dear Dr. Shufeldt:

"After your letter came, Miss Talbot was in the building and I talked to her of some of the difficulties of interpretation of the beast *Podokesaurus*. She is going to make a very careful examination of the pubis and other bones to see if in her opinion there is any indication of their having shifted. She will also have further photographs made of that region of the specimen, as all the photographs sent either to you or to Mr. Heilmann were before the ultimate preparation of the specimen, which was done here at Yale. Her opinion and the photographs should be given due weight and that is the only additional information on the specimen we can get. She is also going to photograph that which she considers to be the hand of the animal, which may give further light.

"When I first saw *Podokesaurus* I thought right away that it was a plant-feeding dinosaur, one of the Ornithopoda, and so advised Miss Talbot. Later, however, when we came to study it in more detail, we both came to the conclusion that it was one of the Theropoda, the evidence lying principally in the structure of the pubic and ischial bones, for I do not think the foot or hand would be indicative of the ordinal condition of so small a dinosaur as this, in the absence of the skull. There is no known predentate or ornithopod dinosaur in which there is not a considerable pre-pubis. If any part of the pubic bone tends to abort, it is, so far as my knowledge goes, the post-pubis or the after limb of the pubic structure. All of them show a forward directed pubic bone, just as the carnivores do, the principal distinction being that in the predentates usually the post-pubis, or, as Huene calls it, the pubis, lies parallel with the ischium. I should under no circumstances consider the animal a sauropod dinosaur, your last question being whether it is possible to decide positively whether it belongs among the Theropoda or Sauropoda. My whole conception of the evolution of the Sauropoda from the Theropoda is based upon the gradual increase of size and the necessity of taking to a semi-aquatic habitat for bodily support and the changing of the diet in order to maintain the bulk, characters which are certainly absent from the creature under consideration. The smallest of the sauropods, which comes from the Potomac, has a length of 10 feet and as yet no Sauropoda are known from Triassic strata.

"With best wishes, very sincerely yours,
(Signed) Richard Lull."

Here the correspondence practically ended, in so far as this subject was concerned; and, personally, I now await what Miss Talbot publishes *after* she has further developed the skeleton of *Podokesaurus Holyokensis* in the matrix. It may throw further light upon the subject and it may not, for the reason that the opposite pubis may not only not be found, but it, likewise, may be out of place when it is.

Then, too, I anxiously await the next instalment of Hr. Heilmann's valuable work, which will doubtless present his side of the argument far more lucidly than I have been able to do here.

In any event I do not believe for an instant that the pubic bone ever occupied any such position in life as Dr. Lull has given it in his restoration, for reasons that I have attempted to set forth in the present article, and for the added reason that we never meet with bones in any vertebrate skeleton—living or extinct—where an extremity of that bone is *expanded* for the purpose of affording a sufficient area in that a *notch*, such as exists in the proximal end of the pubis of *Podokesaurus*, may exist there. A notch of that kind would not be found there unless it had some *definite use*, and the most natural one would be to either articulate with some juxtaposed bone, or to afford a greater amount of surface for ultimate co-ossification, which latter I take to be the case in *Podokesaurus*, where, in addition, it completes a foramen found in both birds and dinosaurs.

The Future of the Steam Locomotive*

A Consideration of the Factors of the Different Motive Powers Available

By John E. Mulfield

THE principal factors that will enter into the steam railway transportation and motive power situation during the ensuing ten years justify the following conclusions:

1st. As the supply and cost of liquid fuels, when compared with coal, lignite and peat,, in the United States and Canada, make their general use for internal combustion types of motive power prohibitive, and as producer gas and storage batteries do not offer any early possibilities, the electric locomotive dependent upon an outside source of power for its propulsion, is the only one that can be considered as being in the same field as the steam locomotive in general railway service.

2nd. The general difficulty incident to adapting electrification to existing steam railway operation will not warrant any considerable change from independently operated steam motive power units because of the prohibitive capital and non-productive cost, unreliability of service, non-adaptability for concentration or distribution of motive power over various parts of the road, inability to utilize full power under a wide range of speed and traction variations, and lack of standardization.

3rd. The future development of the steam locomotive will be along such lines as will produce the maximum hauling capacity per unit of total weight, at the minimum cost per pound of drawbar pull.

4th. The modernized steam locomotive will provide for the transportation department a motive power unit capable of more nearly continuous service, between general repair periods.

5th. New and existing steam locomotives will be equipped to eliminate the production of smoke, soot, cinders, sparks and fire hazard; to utilize the heat now available in exhaust steam and waste gases; to lessen noise; and to reduce the consumption of fuel per unit of work performed.

6th. All steam locomotives will be provided with special and automatic appliances to minimize the liability for accident, eliminate arduous labor, reduce mechanical delay, and overcome the necessity for frequent inspections and adjustments.

7th. Existing steam locomotives having transportation value will be modernized with a view of reducing the cost for operation and enhancing their physical valuation.

8th. The refinements in design, construction and operation that will be effected during the next few years, justifies the prediction that through the combined use of superheated steam, pulverized fuel, fire-box brick arch, feed water heating and compounding, a horse-power hour will be successfully delivered at the tender drawbar of a steam locomotive of great power for 50 per cent less fuel than is now used by saturated steam motive power.

A century has passed since Trevithick, Hedley and Stephenson produced the general arrangement of boiler, machinery and running gear which still forms the basis of the modern steam locomotive.

Since the construction of George Stephenson's "Rocket," which was equipped with a single pair of driving wheels, the principal development has been an increase in the number and size of coupled driving wheels and a corresponding enlargement of the boiler and machinery, in order to provide means for utilizing a greater percentage of the total locomotive weight for adhesion and tractive power, and thereby enable the increasing of the train load.

During recent years the tendency toward greater speed has resulted in larger driving wheels and the application of various combinations of leading and trailing trucks, such as in the Atlantic, Pacific, Mountain, Prairie, Mikado and Santa Fe types, for the purpose of carrying the loads imposed by larger boiler heating surfaces and grate areas. While this change has usually provided a greater sustained boiler capacity, it has permitted the utilization of the maximum weight available for adhesion for the reason that the bridging effect of a combination of leading and trailing truck wheels will increase rather than decrease the permissible ratio between the weight on driving wheels and the tractive power to an extent that the maximum allowable weight of the locomotive available for the production of drawbar pull cannot be used. As it is clear that the propelling power of a locomotive is dependent on the load carried by the wheels of the driving axles, and that whatever weight not so distributed is non-productive, it is easy to discern that the eight-wheel, mogul, consolidation, six and eight-wheel coupled, decapod and Mallet articulated types of locomotives will produce a greater hauling capacity per pound of either total or adhesive weight than the corresponding Atlantic, Pacific and other trailing truck types of locomotives that have superseded them. As improved means of combustion will eliminate the necessity for grates and ashpans and enable the location of relatively large driving wheels adjacent to the firebox, the non-trailing truck types of locomotives will no doubt again come into favor.

Next to the adhesive factor, the steam generator is the all important element and which, in the steam locomotive, is a self-contained part of the motive power unit. In general the maximum power that can be developed by the present day steam locomotive depends upon the maximum rate of fuel consumption which can be maintained per square foot of grate area, the limit being reached when the draft becomes high enough to carry partially consumed fuel out of the stack in the form of smoke, cinders and sparks, which, besides decreasing the effectiveness of the machine, introduces the danger from fire hazard. While the enlargement of grate areas and heating surfaces, improvement in circulation,, and the application of firebox brick arch and tubes have materially increased the boiler capacity, the forcing of the combustion of a large amount of fuel per hour on a limited grate area has increased the quantity of fuel used per unit of work performed far beyond what a more effective means of combustion will produce. However, the burning of fuel in a pulverized form in suspension will materially relieve this condition.

Having regard for the utilization of the steam, with the exception of the Mallet articulated type of locomotives, the general practice now is to use single expansion cylinders. As the thermal effectiveness of a steam engine is, in general, increased by carrying out the expansion of the steam in two or more stages in separate cylinders, the use of compound rather than of simple cylinders, especially with the superheated steam that is now available, provides opportunity for further improvement in locomotive capacity, and in fuel and water consumption. Compounding has been largely discontinued during the past fifteen years, due to the mechanical and operating difficulties (largely influenced by the excessive condensation of saturated steam) that resulted from the various designs which were adopted in the United States during the previous ten-year period. The introduction of the Mallet articulated type of locomotive by the Baltimore & Ohio R. R. in 1903, however, resulted in the revival of the compound system, and in combination with superheated steam, the results have been such as will no doubt again bring about the introduction of the compound type of locomotive in other than the articulated designs. The more recent development of intercepting valve mechanisms will largely overcome the mechanical deficiencies in the previous designs of compound cylinders.

Relative to the unbalanced reciprocating parts that go to make up a considerable portion of the weight of a modern steam locomotive, it has developed, by recent research and experimental work, that through improved

*Railway Review.

design and material the weights of these parts, such as piston valves, valve motion gear, piston heads and rods, cross heads and main and side rods and counterbalancing, may be materially reduced, with the resulting considerable decrease in non-spring-borne parts of the running gear and machinery, as well as in wear and tear on motive power and roadway. The further development of the three cylinder compound locomotive offers particular opportunities in this regard.

A comparison of the thermal efficiency of steam and electric motive power shows that under the average working conditions a hand-fire saturated steam locomotive burning coal on grates and an electric locomotive will each deliver about four per cent of the thermal heat value in the coal at the track rails. When the steam locomotive is equipped with superheater, firebox, brick arch and for burning pulverized fuel, this percentage is increased to about six. The added saving that may be effected through the application of feed water heaters and other appliances whereby the heat now in the waste gases and steam that is exhausted to the atmosphere may be made to perform useful work, offers a practicable means for further substantial improvement.

With respect to the electrification of steam railway lines in the United States and Canada, the initial application was in 1895 in the operation of a relatively long tunnel on the Baltimore & Ohio R. R. in the city of Baltimore. Including that and subsequent installations, exclusive of the Chicago, Milwaukee & St. Paul Railway main line electrification, the primary reasons for the introduction of electric service on steam railways to the present time have not been to expedite the movement of traffic or to effect economies in operation, but to provide for:

1st. Smokeless operation through underground terminals and tunnels, eleven installations.

2nd. Utilization of cheap hydro-electric power, three installations.

3rd. Franchise requiring other than steam motive power, two installations.

4th. Relief of terminal passenger station congestion, one installation.

5th. Development of local traffic, one installation.

This total of eighteen installations made by thirteen different steam railway systems during the past twenty years, aggregates about 625 road miles, out of a total of approximately 280,000 road miles in the United States and Canada, and a comparison of the principal detail, such as the current generating, transmitting, distributing and contact systems, voltages, types of locomotives and the like, will show wide variation and is indicative of the present undeveloped state of the art.

While the costs for installation and for maintenance and operation of these electrified sections of steam lines are either unavailable or difficult to obtain, it would probably be conservative to approximate that a unit of passenger or freight hauling power will cost for first installation from five to ten times more for electric than for steam, and for fixed charge maintenance and operation it will cost from two to three times more for the electric than for steam. For example, should the initial cost of a steam locomotive be $25,000, complete ready for service, an electric locomotive of identical hauling capacity with its necessary propelling auxiliaries will represent a first cost of from $125,000 to $250,000.

Where adequate water power can be utilized economically in combination with a load factor of 75 per cent or more to reduce operating costs; where relatively small train loads and rapidity and frequency of service obtain in congested districts of dense passenger traffic; or where the transportation operations are auxiliary to mining or other industrial developments requiring the extensive use of electricity, there may be some justification for the use of electric motive power. However, the disadvantages that will still remain as compared with steam, may be stated as:

1st. The almost prohibitive cost for installation, operation, interest, taxes and depreciation, except where unusually cheap hydro-electric power and a high road factor are obtainable.

2nd. The necessity for incurring large capital investments and discarding existing locomotive, car, track, signaling and supply equipment, and road and terminal facilities.

3rd. Inability to utilize more than an average of from one third to one half of the power generating capacity, due to low load factor, and for maintaining additional emergency power generating equipment.

4th. Non-interchangeability of equipment over other than electrified home districts, due to lack of standardization in current and contact systems.

5th. Liability for dangerous and expensive short circuiting at power stations or on the line, with consequential fire, suffocation, personal injury and fatalities.

6th. Dependence upon an outside source of power generating, distributing and contact system for operation, resulting in complete stoppage of all locomotives in event of failure.

7th. Interference of storms, snow, sleet and floods with operation.

8th. Necessity for duplicating and patrolling long distance transmission lines to insure against current supply failures.

9th. Electrolysis of water, gas and other metal mains and structures.

10th. Short circuiting and leakage of current, due to defective insulation and bonding, and on account of unfavorable weather.

11th. Liability for "overheating" of motor equipment after short, heavy runs, necessitating "resting" of locomotives at terminals.

12th. Extraordinary expense for upkeep of track and contact line surface alignment.

13th. Delays in changing locomotives at the termini of the electrified and steam zones.

14th. Necessity for a more skilled class of labor for inspection, maintenance and operation.

15th. Increased delay and constructive mileage for motive power and crews.

16th. Inability of the electric locomotive to utilize its rated capacity and effectiveness throughout the same range of speed and tractive power variations as the more flexible steam locomotives.

17th. High initial and consequently greater fixed cost to be added to the operating expense per unit of power developed.

18th. Difficulty in adapting electrification generally to existing steam road practice.

Given a certain trackage equipped with fuel, water and sand supply, turning and slag-pan dumping facilities, a modernized steam locomotive may be successfully operated. However, an electric locomotive in lieu of these facilities would require for its operation one or more fireproof power generating stations; general and auxiliary feeder and distributing systems; general transformer, converter or storage battery sub-stations; overhead or surface contact lines; track rail bonding and insulation; safety cut-out switches; electro-magnetic disturbance neutralizers, and the like, each item of which is made up of innumerable complicated and costly details for installation, maintenance and operation. Therefore, the financing of projects involving the electrification of steam railway lines will be somewhat different until it can be demonstrated that electrification will produce net results that cannot be obtained from steam operation.

The agitation for electrification has stimulated mechanical engineers engaged in designing steam motive power to attack the various problems confronting them along vigorous lines, with the result that while the interchangeable steam locomotive is rapidly becoming a more effective and economical machine under all conditions of weather, speed and train-load, the electric locomotive, from an engineering standpoint, has not yet reached any comparative degree of general standard design, method of operating, reliability or efficiency.

Since the initial application of electricity on the Baltimore & Ohio Railroad, and particularly during the past ten years, a tremendous advance has been made in the perfecting of the steam locomotive through the use of larger single units of power, in the application of special appliances for producing effectiveness and economy and through general and detail improvements in design, material and construction.

Prior to the development of the Mallet and other locomotives of great power having boilers equipped with high steam pressures, superheaters, large grate areas, firebox brick arches, compounding and other capacity-producing devices, the accelerating qualities and the endurance of the electric locomotive at speeds on grades was regarded as an advantage over the saturated steam locomotive, even though its limited steam capacity was no greater handicap in the development of maximum hauling capacity than the overheating of the motors of electric locomotives. However, the past ten years development of the steam locomotive has brought about a material change; for example, the use of superheated, as compared with saturated steam, has not only increased the capacity of locomotive operation approximately 33⅓ per cent, but it has at the same time enabled a saving of approximately 25 per cent of the fuel and 33⅓ per cent of the water used per unit of work performed for the reason that in single expansion cylinders an indicated horse-power hour may be produced for from 15 to 20 pounds of superheated steam, as compared with from 26 to 32 pounds of saturated steam, and a horse-power hour may now be delivered at a tender drawbar, through the complete range of the effective capacity of the locomotive, for approximately three pounds of coal.

In general, therefore, it may be conservatively concluded that the steam locomotive will remain the standard unit of motive power for present and future general railway operation for the reason that its existing merit and the possibilities for improvement fully justify its continued use.

Improving the Physique of Americans*

Humboldt declared that "Whatever virtue men would have appear in society must be taught in the schools." It is upon these nurseries of civilization that we must rely to reawaken the physical conscience and to show to future generations that, by taking thought, they can not only free themselves from disease, but can attain a vigor of intellect and a strength and beauty of body not seen on earth since the days of the ancient Greeks.

The following plan is proposed as a direct and efficient method of teaching the masses what the body beautiful should be, and what steps are necessary to secure this great desideratum.

The number of teachers and experts necessary to carry it out will be no greater than the extra teachers now employed in our public schools to distract the children's minds from the fundamental studies of the curriculum by inculcating in a vague way a smattering of various more or less immaterial subjects. Teachers, parents, and everyone else at this writing, acknowledge that health comes first, and that the whole system of education must be made to conform to this axiom in very deed, even as it now professedly conforms to it in theory.

To begin with, we must fain acknowledge that there is no question that much of the present drive to conserve and improve the health of school children begins too late. It is in the improper treatment of the little children that most of the seeds of future trouble are sown. If small scholars were carefully watched, and each one minutely studied for any congenital defects, as well as for any fault of environment, there might result an enormous saving to the State by reason of the diminution in the numbers of dipsomaniacs, neurasthenics, insane, and incompetent people. Starting the education of numbers of congenitally defective children in our public schools, and pushing them along, until their condition is made worse and harder to remedy, is an error which we are learning to avoid. But we are not so careful to avoid and not so successful in combating injury not alone to the delicate, underdeveloped, and undernourished children, but even to the normally healthy ones, by improper physical conditions in the schools.

The principal reason for this failure, which is so far-reaching, and so general that its importance cannot be overestimated, is that we neglect the physical status of the young scholar until more or less harm has been done. We are trying to make bricks without straw by pushing all the young scholars along the road of education just so many feet every year, all the while neglecting the two essential features, first, whether the child has the normal equipment, physical and mental, for the work, and second, whether the work is in any way injurious to him.

School teachers have a notion that so long as the child keeps up with his grade, and no complaints of ill health are made, he is doing well enough and there is nothing to worry about. There are a great many rules and tables to determine what the mental status of a child should be at a certain age, and for that matter, there are enough rules to show what the average child's physical development should be at a given age. Unfortunately, however, the teachers do not know the latter rules, however well they may be acquainted with the former; nor are there any tests of the physical status of the scholars in the regular school work that are as easily applied and as efficient as the tests of their mental work, always at hand in their marks for their recitations and their periodical examinations.

Consequently the average teacher is not at present capable of judging whether the child is being injured by the school work, or whether the child has the normal physical development for his age. The medical inspector of the school is not engaged to do this essential work, so it is not done.

There is, therefore, not only the danger of a lasting injury to the child by allowing him to live under improper conditions, both in and out of school; there is also the further unfortunate circumstance that his physical development is neglected. From both of these causes the average school child suffers injuries that are most vital, both in their immediate and remote results. "As the twig is bent, the tree is inclined." Our interference with present conditions must not be solely of a negative character; we must take positive steps to assure the best

* An abstract of an article in the *Medical Record*.

mental and bodily development if we wish to give every scholar a fair chance to grow up to the full measure of his potential abilities. As an incentive to everyone directly interested in this vital question, the parents, the teachers, and especially the child, the following simple plan is proposed: To begin with, there should be careful physical examination at least monthly of every scholar by qualified inspectors under the control of the medical inspector of the school. The teachers could easily learn to assist the medical officer and should perform most of the detail work necessary for the proper examination and rating of their own scholars. This aspect of the matter will be taken up again in this paper.

Cards should be made out in duplicate, scoring the child, as dairies are now scored. Height, weight, lung capacity, strength, etc., should be recorded and compared to the normal for the scholar's age. The condition of the eyes, teeth, tonsils, throat, hands, feet, and genital organs should be noted. Special examination should be made for rupture, scoliosis, enlarged veins, enlarged thymus and thyroid glands and abnormal conditions of the lymphatic glands, spleen, and liver. The state of the tongue, conjunctivæ, complexion and skin generally, should be noted. Also the care of the body, whether clean or dirty, whether the finger and toe nails are clean and well trimmed, whether hair and scalp are clean and properly cared for. Bow-legs, [illegible], enlarged joints, flat feet, or any malforma[illegible]ease of the bones should also be especially note[illegible] credit should be given for everything normal, and extra marks might be allowed for especially good points, like a perfect denture, marked cleanliness of body, etc., while certain specified reductions in the marks should be made for congenital malformations such as club-foot, flat-chest, strabismus, hunch-back, etc.

One of the aforementioned cards should be sent to the parent or guardian and one filed in a card-index to be consulted at the next examination. Stooping shoulders, spinal curvature, corns, eruptions, ringworm, itch, decayed teeth, pediculosis, spongy gums, coated tongue, and other remediable conditions should be reported and, if reasonable efforts are not made to correct them, the child should be debarred from a rating at the next examination. This would endanger his chances in competing for the health and beauty prize, to be hereafter described. If especially good corrective work has been done, extra marks might be allowed.

This monthly rating should be continued until the child graduates from the primary or grammar school and at the close of each school year there should be an accounting. If the marks for physical rating for the year fall below a certain minimum the pupil should be debarred from promotion to the next grade in the school. If, however, the aggregate of credits exceeds the minimum, a medal for good physical condition should be presented to the child, and if the total credits reach a specified height, extra credits should be granted. The medal may be of some ordinary metal, as copper or brass, but pretty enough to be attractive. Absence from school for sickness or otherwise should be noted in the summing up of the marks, and might affect the rating. The minimum in the lower grades, at least, should not be placed so high as to debar an average child, whose parents or guardians will make a serious effort to correct the defects noted.

The teachers themselves should all be required to undergo a severe physical examination before their appointment to teach and at least annually thereafter. For schools in the vicinity of New York city the recently established Life Extension Institute would no doubt gladly undertake the periodical examination of the public school teachers, and would recommend to them any alterations in their mode of life that might be necessary to conserve their health and efficiency. So far as known, Dr. Greenwood's plan as carried out in Blackburn, England (of which city Dr. Greenwood was, and probably is yet, health commissioner, as we would call him in New York), for enlisting the teachers actively in the health work of the public schools has never been tried in America. He, however, gave it a good trial in the Blackburn schools, and speaks highly of the result. The plan was essentially to make "the teachers our first line of defense," especially those teaching in the lower grades. He established a course of lectures on personal and school hygieae for the teachers and gave an examination at the conclusion of the course. I believe that only those who wished to do so took the examination. But those who passed it creditably received a certificate that they were competent to teach the rudiments of school and personal hygiene and were allowed an increase in their salaries. According to Dr. Greenwood, their work in this direction was satisfactory to him and a great source of satisfaction to the teachers themselves. Their school tasks were more interesting, and their own and their scholars' health was benefited by this innovation and by the simple sanitary regulations which they inaugurated for their own and their scholars' benefit.

Of course, this scheme will probably fail in execution unless a full time medical director is engaged in every school. He or she must be an enthusiast for the combined physical and mental education of children and must be a specialist in that line of work. He must have control of, and be responsible for, the hygiene of the school-houses and of the school-rooms. He must prevent over-crowding and over-heating of the rooms and over-working of the scholars. He must superintend the examinations of the latter called for in the foregoing plan and must be responsible for the proper filing and accuracy of the score cards, and must know that the children and their parents are given proper directions for conserving their health, and for correcting and remedying any remedial defects noted in any of the cases. He must also be competent to supervise and superintend all the athletic sports and exercises of the scholars and must be particularly alert to prevent any injury to any pupil by improper or too strenuous exercises. He must see that every teacher and scholar gets the requisite exercise, and must instruct the former in the simple rules of personal and school hygiene and must see that these are enforced. In short, he must have such authority as is now given in civilized countries to naval and military surgeons, whose word in hygienic and sanitary matters can be contravened only by the commander-in-chief.

There is no reason why this plan should not be put in practice in any city. It would soon be followed by a decided improvement in the present rather anemic character of much of the teaching in the lower grades. Teachers would learn to look upon their small pupils as human beings with minds and bodies to cultivate—and not merely as receptacles into which "learning" is to be introduced. Furthermore, the teachers would find themselves so much stronger and better in body and mind that they would begin to feel more respect for themselves, and a more vital interest in their work.

Naturally this plan will take time for its development and will doubtless meet with considerable opposition. Yet, I believe that it, or some modification of it, will prove entirely workable.

By the adoption of these health and physical excellence prizes, by instructing the teachers in the elements of school hygiene, and by enlisting everyone in the health and physical well-being contest, a great step toward better general health conditions will have been taken. Everybody interested in the school will be perforce drawn into the movement. The parents could scarcely fail to be deeply interested. Small leaflets should be printed and distributed throughout the town at the beginning and the close of each school year, calling attention to the prizes and the rules of the contest, and the child's monthly health card should in every case be transmitted to the parent promptly and attention called to any remediable defects in the child's health or habits. Health lectures to parents, with special reference to the winning of the health prizes, should be instituted and given by the school medical inspectors at least monthly through the school year.

The expense of the movement need not be great. Even if it were, the reward in the greatly increased interest in everything connected with health, hygiene and the bringing up of children would be of incalculable benefit to the schools, and to the community at large. If it did increase the taxes somewhat, the resulting benefit would be so obvious that no thoughtful person would think of finding fault with the scheme. The extra expense would be saved to the state many times over, by the resulting decrease in criminals, degenerates and imbeciles, and by the development of a higher and finer and more efficient average citizen and voter.

Utilization of Nettle Fiber

Dr. Oswald Richter, professor of botany at the University for Agriculture in Vienna, prophesies that as a result of his experiments with nettle fiber Austria will become independent of foreign cotton. The authorities have decided to organize and to prepare for the use of the new material. In the spring nettles will be planted and cultivated in the entire Monarchy, and after the harvest in the fall the cultivation of the nettle will begin on the most extensive lines. In this only such soil will be cultivated, mostly along rivers, as is not fit for other use.

In his efforts to separate the fiber of the nettle, Prof. Richter used ammonia with success, but the high cost of this method made it appear commercially unprofitable. Further experiments (so Prof. Richter stated in a recent lecture) have proved that the fibers may be separated with water. He has also simplified the process of separation. For this reason he believes that the cultivation of nettles will be found profitable even in time of peace.

During the lecture Prof. Richter exhibited articles made from the nettle fiber. He first showed the simple fiber, which had the appearance of hemp, and then the thread on large spools which seemed to differ in no respect from cotton thread. A ball of cotton yarn next attracted attention, and finally a pair of socks, knitted from this cotton, which were dazzling white and fine texture. Cord looking like the ordinary coarse cord was also shown, as was "cotton batting," which would be useful for dressing wounds.

Because of its great receptivity of certain elements it is adapted for the mantles of the Welsbach lights. Furthermore, it absorbs many colors and can, therefore, be dyed well. Finally, it can easily be made waterproof.—*United States Commerce Reports.*

SCIENTIFIC AMERICAN SUPPLEMENT

Founded 1876

NEW YORK, SATURDAY, AUGUST 5th, 1916.

Published weekly by Munn & Company, Incorporated

Charles Allen Munn, President; Frederick Converse Beach, Secretary; Orson D. Munn, Treasurer; all at 233 Broadway, New York

Entered at Post Office of New York, N. Y., as Second Class Matter

The Scientific American Publications

Scientific American Supplement (established 1876) per year $5.00
Scientific American (established 1845) . . . . " 3.00

The combined subscription rates and rates to foreign countries, including Canada, will be furnished upon application

Remit by postal or express money order, bank draft or check

Munn & Co., Inc., 233 Broadway, New York

The purpose of the Supplement is to publish the more important announcements of distinguished technologists, to digest significant articles that appear in European publications, and altogether to reflect the most advanced thought in science and industry throughout the world.

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